Report to the U.S. Department of Transportation

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ITS STANDARDS TESTING PROGRAM

Test Report for NTCIP Dynamic Message Signs

D R A F T

Prepared by:

Battelle Memorial Institute

Columbus, OH

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Introduction

This report presents the results of the Intelligent Transportation Systems (ITS) Standards Testing Program for the field testing, assessment and evaluation of six National Transportation Communications for ITS Protocol (NTCIP) standards that apply in the domain of Dynamic Message Signs. These six standards are identified in the following sections.

This report is Volume 2 in a series of three volumes that report these findings. Volume 1 is an Executive Summary Report. Volume 2 (this report) provides summary detail on the testing process, test environment and conditions, analysis and evaluation results, findings, conclusions and recommendations. Volume 3 contains the complete detail repository for all questionnaires, MOU, documents, interviews, test data files and information collected and examined in the planning and conduct of this testing process.

Overall Finding

The six standards tested were assessed and evaluated as suitable, effective and as contributing positively to the interoperability and interchangeability of NTCIP DMS subsystems except as discussed in the findings stated in this report. In the specific testing of 19 DMS core functions and features included in the NTCIP 2101 and 2103, there was only one exceptional finding noted with the Scheduler features.

The conclusion of the independent test team is that the DMS-specific standards 2101 and 2103 are relatively mature and have enabled two independent vendors to create fully-functional NTCIP DMS subsystems. Further, with the standards-related exceptions noted in this report, these two subsystems have the potential to be fully-interoperable and interchangeable in a mixed product operational environment."

Background

As part of the ITS Standards Test Program (ISTP) review of applicable standards, 50 standards were deemed testable. It has been the intent of the ISTP and the ITS Standards Test Team (ISTT) to test each standard for its contribution to interoperability via testing of a deployed ITS standards compliant system. For purposes of the ISTP, interoperability is understood to be more encompassing than the standard interoperability definition of "the ability to use many different types of devices on the same communications channel". Clearly the point of the ISTP is to ensure more than just the ability of one device to not interfere with another device. Just as clear though, is that the ISTP is not concerned if two devices have such identical physical, electrical, embedded software characteristics that they can be used interchangeably.

Instead what the ISTT is actually testing is the standards ability to facilitate the manufacture of devices that have essentially limited interchangeability. The interchangeability is limited within the domain described by the applicable standards (that of embedded software features) and constrained

operationally by the Core Functionalities. For DMS's, that means that within the domain described by the six NTCIP standards, if all the DMSs perform the Core Functions identically, they will achieve the desired level of interoperability. Through the remainder of this document the term interoperability is used to define this desired middle-of-the-road, limited condition.

The first device chosen for testing was the DMS. There are six NTCIP standards that apply to the DMS subsystems, these are listed below:

1. 1101 NTCIP – Simple Transportation Management Framework (TS 3.2)
2. 2001 NTCIP - Class B Profile (TS 3.3)
3. 2301 NTCIP - STMF Application Profile (TS 3.STMF)
4. 2101 NTCIP - Point-to-Multipoint Protocol/RS232 Subnetwork Profile (TS 3.PMP232)
5. 1201 NTCIP - Global Object Definitions (TS 3.4)
6. 1203 NTCIP - Object Definitions for Dynamic Message Signs (TS 3.6)

These six NTCIP DMS standards were tested, assessed and evaluated through a detailed process of pre-test technical examination and analysis, vendor interview, static analysis and most importantly, through hands-on field-testing of deployed, operational product implementations. The results of the pre-test assessment guided the development of vendor questionnaires and subsequent test procedures. It should be noted that only those aspects of the standards that specifically apply to NTCIP DMS devices were evaluated. In cases where these standards simply referred to other International Standards Organization (ISO), Request For Comments (RFC), etc. standards, those standards included by external reference WERE NOT tested or evaluated.

The field testing phase was conducted in early March at the Illinois State Toll Highway Authority in Downers Grove, Illinois. The Illinois State Toll Highway Authority (ISTHA) was chosen as the first test site because of their willingness to facilitate the testing process and the maturity of their deployed systems. The ISTHA is currently deploying over 30 NTCIP compliant DMS devices on the regional toll ways in northeastern Illinois. These signs at present come from two vendors. The ISTHA has completed acceptance testing on the two vendor's signs and control software suites using the same test procedures for both. Both suites passed these tests with exceptions. It was stated in general that the vendors attribute these exceptions to their specific interpretation of NTCIP standards generalities or ambiguities—which (apparently in this case) manifests as a deviation from the expected results contained in the test procedures.

The ISTHA also tested the control and operation of each vendor's NTCIP compliant sign with the other vendor's control software with mixed success. It is an ISTHA requirement that each vendor's roadside controller and attached DMS, from two or more vendors, be controllable by the other's center control software.

Core Functions – One Exception

These core functions include the operational functions that typify a DMS, and therefore, are paramount when assessing and evaluating the suitability, effectiveness and interoperability/interchangeability of the standards. Of the 19 functions tested, a single exceptional condition was noted--this exception was with the Scheduler activation mechanism. Since the

Scheduler lacks an object to enable (run) the schedule, or disable (stop) the schedule, the vendor's at this site have developed "custom objects" to accomplish the desired control. While NTCIP compliant, this approach leads to non-interoperable DMS subsystems.

Conclusion

With the exception noted above, all of the standards related to the DMS tested to be suitable, effective and contribute positively towards interoperability/interchangeability. Overall the operational performance of the DMS Standards, when properly implemented, can lead to an effective, efficient and interoperable/ interchangeability system. However, it was determined that a DMS deployment can be implemented following the DMS standards, but remain non-interoperable. Therefore the DMS standards do not ensure interoperability/interchangeability.

Summary of All Exceptional Findings

The complete presentation and discussion of all findings can be found in the main body of this report.

There are 24 findings collected in three categories: six Interview Comments (IC), six Test Results (TR) and twelve from static Analysis of Standards (AS). These findings were rated as to their Effect (e.g., negative, neutral, positive) on the NTCIP DMS standards domain, and the Severity of that effect (e.g., critical, serious, major, minor).

In summary, there were 15 negative and 9 neutral findings; of these, one is serious, 13 are major and 10 are minor:

	Negative	**Neutral**	
Critical	None	None	None
Serious	1	None	1
Major	11	2	13
Minor	3	7	10
	15	**9**	**24**

The following table enumerates the negative findings by topic and illustrates that these exceptional negative conditions are but a small subset of all the features of the standards tested (see Tab C).

	Finding Topic Area	General Issues Discussed in the Finding
Serious	Community Name Index (AS-6)	An object in the mandatory Security Conformance Group appears to be improperly coded as "not-accessible".
Major	**Scheduler (IC-1, TR-1)**	**The standard is incomplete in that it lacks a scheduler object to enable/disable the running of the schedule (a Core Function as mentioned earlier)**
	Power Supplies (IC-3, TR-4)	The standards are incomplete in that they lack support for multiple power supplies.
	Light Sensors (IC-4, TR-3)	The standards are incomplete in that they lack support for multiple illumination sensors.
	Illumination Brightness (TR-5)	The definition of brightness levels is inconsistent and ambiguous.
	External References (AS-2)	There are numerous external references to non-ITS standards that may be inconsistent.
	LAPB MIB (AS-4)	There are compatibility and usability issues with a reference to RFC 1381.
	Gauge Syntax (AS-5)	This is a syntax error in the MIB.
	Event Configuration (AS-7)	There are correctness and usability issues associated with the detection and management of events.
Minor	No Graphics Capability (IC-5)	Vendors identified this as a needed feature in the standards.
	Message CRC (TR-6)	The CRC is calculated using the message, beacons and pixel service settings. Vendors may use different default settings for these last two parameters leading to incompatible CRCs.
	Sign Housing Temperature (AS-1)	The temperature range of 0-255 ^{o}F seems in error.

Introduction

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This report is Volume 2 in a series of three volumes that report these findings. Volume 1 is an Executive Summary Report, Volume 2 (this report) provides summary detail on the testing process, test environment and conditions, analysis and evaluation results, findings, conclusions and recommendations. Volume 3 contains the complete detail repository for all questionnaires, Memorandum of Understanding (MOU), documents, interviews, test data and information collected and examined in the planning and conduct of this testing process.[1]

Background

ITS Standards Testing Program

The Intelligent Transportation System (ITS) Standards Testing Program has been undertaken by the U.S. DOT to test, assess and evaluate the body of ITS standards now being published individually or jointly by one or more of several Standards Development Organizations (SDO)[2]. Of the approximately 80 ITS-specific standards, approximately 50 have been identified as "testable" in this program. It is therefore the stated intent of the U.S. DOT to test each of these 50 standards in a field operational environment to assess and evaluate each standard's suitability, effectiveness and contribution to interoperability/interchangeability.

Which Standards Were Tested

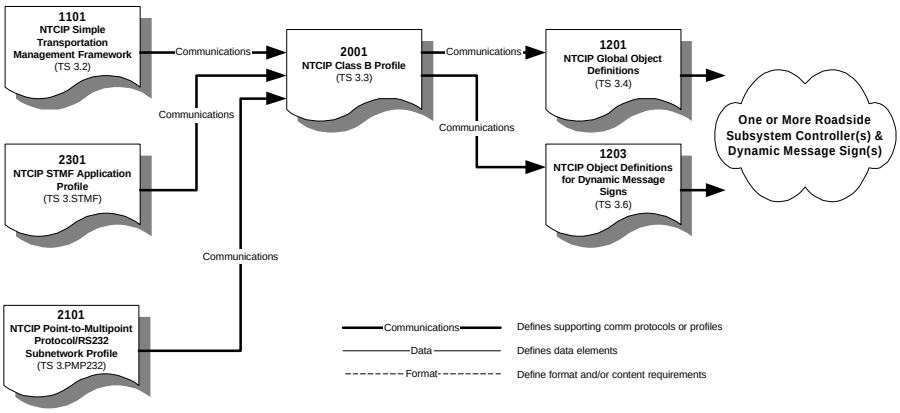
This report contains the results from field testing a specific subset of the standards applicable to the operation and control of dynamic message signs (DMS). This particular domain includes standards developed exclusively by the AASHTO. The six standards tested are:

1. 1101 NTCIP – Simple Transportation Management Framework (TS 3.2)
2. 2001 NTCIP - Class B Profile (TS 3.3)
3. 2301 NTCIP - STMF Application Profile (TS 3.STMF)
- 2101 NTCIP - Point-to-Multipoint Protocol/RS232 Subnetwork Profile (TS 3.PMP232)
4. 1201 NTCIP - Global Object Definitions (TS 3.4)
5. 1203 NTCIP - Object Definitions for Dynamic Message Signs (TS 3.6)

1 Volume 3 contains product specific proprietary and/or competition sensitive data and information that **will not be released** to the general public except with the explicit prior written agreement or waiver of all concerned parties including: (1) the host site ISTHA, (2) the vendors, and (3) the ITS Standards Testing Program Manager at U.S. DOT.
2 The SDOs are: IEEE, AASHTO, ITE, NEMA, …

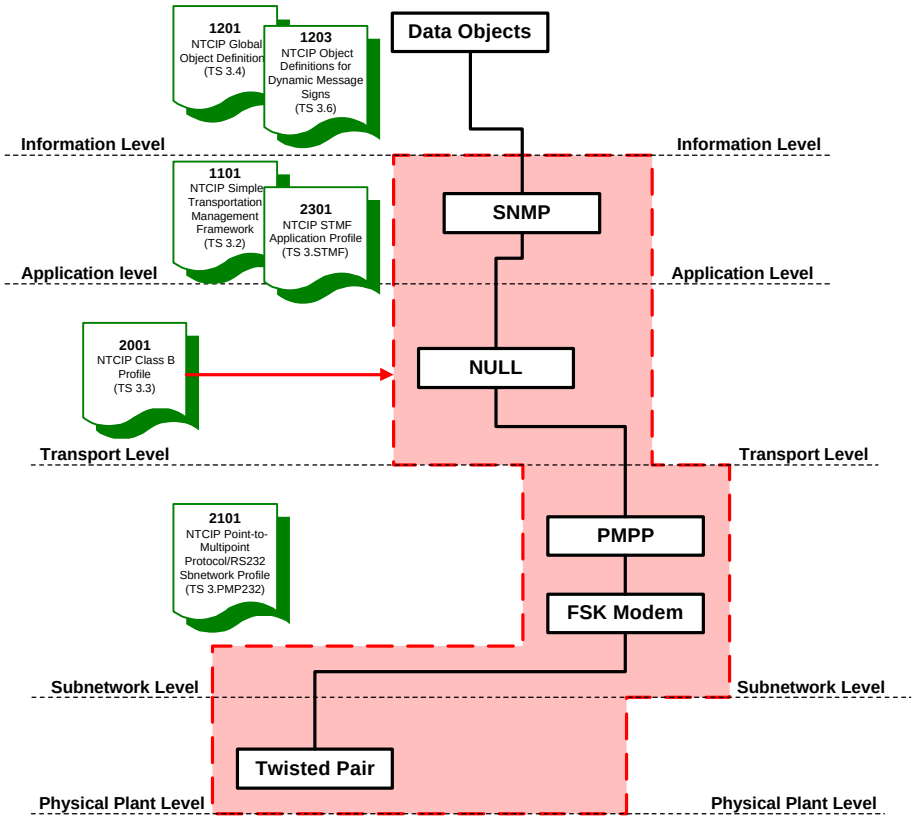
These standards are related to each other, and to the NTCIP standards framework in several ways. In terms of the ITS standards taxonomy, these six standards are related and interdependent as shown in Figure 1.

Figure 1: Standards Taxonomy for NTCIP DMS



Another viewpoint of how these six standards relate is to examine their relationship to the defined NTCIP standards framework for Center-to-Center and Center-to-Field communications as a layered protocol stack[3]. This relationship is illustrated in Figure 2. The highlighted path through this framework illustrates the high-level communications test conditions at the ISTHA test site.

Figure 2: Standards within the NTCIP Framework



3 This information derived from *The NTCIP Guide*, NTCIP 9001 v02.05 (Draft), September 1999

As shown in Figure 2, the NTCIP framework uses a layered or modular approach to communications standards, similar to the layering approach adopted by the International Standards Organization (ISO). In general, data communications between two computers or other electronic devices can be considered to involve the following primary layers, called "levels" in NTCIP to distinguish them from those defined by ISO:

1. **Information Level (1201, 1203)** – This level provides standards for the data elements, objects, and messages to be transmitted. Information Profiles define the meaning of data and messages and generally deal with ITS information (rather than information about the communications network). This is similar to defining a dictionary and phrase list within a language. These standards are above the traditional ISO seven-layer stack.
2. **Application Level (1101, 2301)** – This level provides standards for the data packet structure and session management. Application Profiles define the rules and procedures for exchanging information data. The rules may include definitions of proper grammar and syntax of a single statement as well as the sequence of allowed statements. This is similar to combining words and phrases to form a sentence or a complete thought and defining the rules for greeting each other and exchanging information. These standards are equivalent to the Session, Presentation and Application Layers of the ISO seven-layer stack.
3. **Transport Level (Null)** – This level provides standards for data packet subdivision, packet reassembly, and routing when needed. Transport Profiles define the rules and procedures for exchanging the Application data between point 'A' and point 'X' on a network. This includes any necessary routing, message disassembly/re-assembly and network management functions.
4. **Subnetwork Level (2101)** – This level provides standards for the physical interface (e.g., modem, network interface card, etc.), and the data packet transmission method. Subnetwork Profiles define the rules and procedures for exchanging data between two adjacent devices over some communications media.
5. **Physical Plant Level (twisted pair)** – This level consists of the physical transmission media used for communications. The Plant Level is shown in the NTCIP Framework as a means of providing a point of reference to those new to NTCIP. The Plant Level includes the communications infrastructure over which NTCIP communications are intended. The NTCIP standards do not prescribe any one media type over another.

This background information further illustrates that the NTCIP information level standards used by ITS are unique to the transportation industry. The National ITS Architecture and on-going standards development effort involves identification of required data elements and their compilation into standard objects or message sets for all the domains and functions within ITS. For the subnetwork and transport levels, ITS utilizes existing standards developed and used within the broader computer and telecommunications industries. NTCIP has not developed significantly new standards in these areas, but has merely chosen which existing standards are to be used in ITS (adopting Internet standards where possible), and using profiles (e.g., 2001 NTCIP Class B Profile) to specify which options to use where alternatives are available in these widely used standards.

The Test Site

The Illinois State Toll Highway Authority (ISTHA) was selected as the first test site for NTCIP DMS standards. The Illinois State Toll Highway Authority is in the first phase of an incremental deployment program for over 30 NTCIP compliant DMS on the toll highways serving the Chicago metropolitan region and northeastern Illinois. The six signs presently deployed and operational come from two vendors: Daktronics and Vultron. A follow-on procurement of fourteen NTCIP DMS, a next step included in the "over 30" goal, will follow from one or both of these, or a new third vendor. The ISTHA has completed acceptance testing on the two vendor's signs and control software suites using the same test procedures for both.[4]

4 This acceptance test procedure was derived from the Daktronics Virginia DOT (VDOT) procedure.

The products deployed at ISTHA have successfully completed their unit, integration, and system testing. Additionally, ISTHA offered a unique environment in that they had already tested the control and operation of each vendor's NTCIP compliant sign with the other vendor's control software. This provided unique pre-test insight into the likely situation related to the interoperability/interchangeability of these two NTCIP DMS system components. It is an ISTHA requirement that each vendor's roadside controller and attached DMS, from two or more vendors, be controllable by the other's center control software.

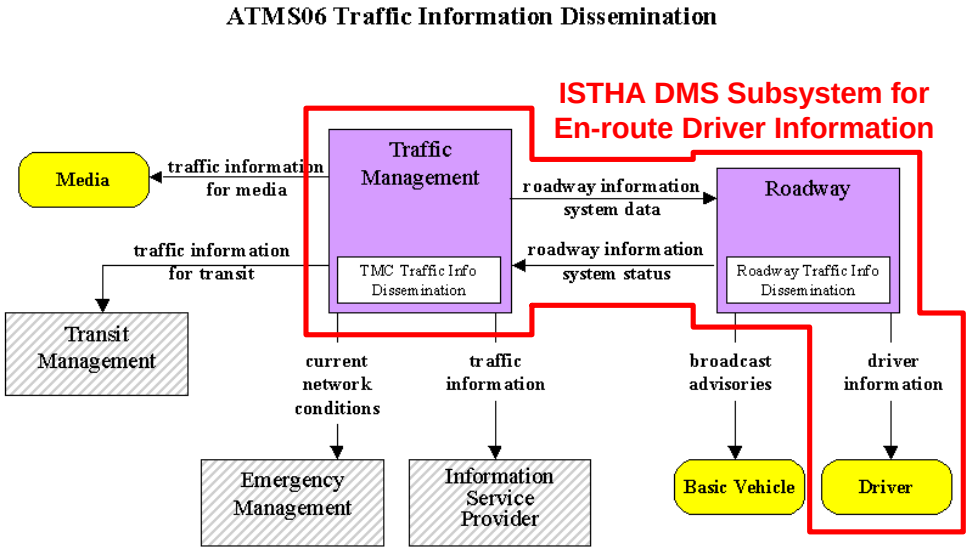
Lastly, but perhaps most importantly, ISTHA was selected because of their willingness to host and facilitate the testing process, their approach to ITS deployment, and the maturity of their deployed and operational systems.

ISTHA: National and Regional ITS Architecture

The NTCIP DMS subsystem test articles used at ISTHA are the en-route driver information component of the regional Traffic and Incident Management System (TIMS). In particular, the toll highways operated by ISTHA are a critical infrastructure component in the system of expressways and toll highways serving northeastern Illinois and the Gary-Chicago-Milwaukee (GCM) Corridor.

In terms of the national ITS architecture, the ISTHA center-to-roadside DMS subsystem implementation maps directly into, and is consistent with the National ITS Architecture and Standards Program. The ISTHA system fits precisely within the architectural definition afforded by the Traffic Information Dissemination (ATMS06) market package as illustrated below. The specific equipment packages of interest are: *TMC Traffic Information Dissemination* and *Roadway Traffic Information Dissemination*. The architecture flows are: *roadway information system data* and *roadway information system status*. The ISTHA DMS subsystem equipment packages and architecture flows of interest are as illustrated and highlighted in Figure 3.

Figure 3: ISTHA DMS Component of National ITS Architecture



Testing Process Methodology

This section presents and discusses the scope of the testing process methodology and the implementation of that plan. The following two key points are important and necessary relating to the interpretation of test results and the implicit use of vendor products:

> **Disclaimer:** This test **is not** an ISTHA, Daktronics or Vultron system standards compliance, functional, acceptance or stress test and shall not be construed as such. Additionally, this test **is not** a side-by-side comparison of Daktronics or Vultron products and shall not be construed as such. All useful data or information of this nature that is collected incidental to the primary focus of standards testing will be shared freely and privately only with the host test site and appropriate vendor for their consideration and use.
>
> **De-identification:** The discussion of observations, facts, results and findings expressed in this report will be vendor de-identified as much as possible. That is, this document **will not** associate or attribute specific test observations with a particular vendor or product. This document will state the observations, findings and recommendations relative to the standard of interest, exclusive of any ties to a specific vendor's use or interpretation of that standard.

Scope of Test

This test addresses the specific observable and testable features of the six identified NTCIP Series standards as they enable core functionality, communications protocols, and global and specific DMS objects. These observable and testable features are embodied in many operational functions required of, and provided by, the ISTHA DMS component subsystems developed by the two DMS product vendors. Please note the distinction between the test items that are drawn from field installations and the testable features that are drawn from the standards. NTCIP devices can have many features that are not described in the standards. This is an important characteristic.

The focus of this test is on features specified in the ITS standards as they are embodied in the test items. The test is not a system acceptance test which compares the behavior of the test item to the functional and/or contractual requirements stated in an RFP, specification or contract. Rather, this test addresses only the features specified in the applicable NTCIP standards.

Conversely, there is the possibility that the present and future DMS technologies will require the standards to address features that are not currently included. The scope of the testing process is designed to identify and report these important issues as well.

Testing Goal: Suitability, Effectiveness, Interoperability/interchangeability

The overall goal of the ITS Standards Testing Program is to assess and evaluate the **suitability, effectiveness** and (contribution to) **interoperability/interchangeability** of ITS standards.

To best focus on the process to assess and evaluate ITS standards, the test team has identified three key elements: (1) suitability, (2) effectiveness, and (3) contribution to interoperability/interchangeability; as essential in understanding whether or not a particular standard is ready for field use. These three high-level categorical elements for assessment and evaluation are defined and expanded in the following discussion. The subsequent tables define and illustrate how several measurable sub-elements can be mapped to these general categories for use in assessment and evaluation.

Suitability

The dimension of suitability addresses those aspects of a standard that make it appropriate for a given purpose, easy to understand and use, or the contrary. This also includes issues and measurements relating to a standard's completeness and coverage when defining all aspects of the problem domain and providing access to, and control of, the appropriate technologies. The impact of an unsuitable standard tends to happen early in the system development life-cycle by needlessly complicating or subverting the choice from suitable alternative standard(s). This assessment and evaluation of suitability will be based on quantitative and qualitative analysis of: (1) structured questionnaire responses, (2) analysis of the standards, and (3) analysis of product capabilities, requirements and design tradeoffs.

Effectiveness

The dimension of effectiveness addresses those aspects of a standard that make its use the best means to achieve the intended or desired effect. This also includes issues relating to how well the features of the standard enable a reasonable and effective implementation in terms of performance requirements and other such operational and maintenance criteria. The impact of an ineffective standard will tend to happen during design and implementation of the system in terms of excessive resource requirements, negative effects on schedule, product performance, etc. The assessment and evaluation of effectiveness will be based on quantitative and qualitative analysis of: (1) structured questionnaire responses, (2) analysis of the standards, (3) operational use, and (4) results from test trials.

(Contribution to) Interoperability and Interchangeability

The dimension of interoperability addresses the assessment of those aspects of the standard and product external interfaces that embody its features and that contribute favorably to achieving the following:

> (ISO/TC204) "Interoperability is the ability of systems to provide services to and accept services from other systems and to use the services so exchanged to enable them to operate effectively together."

Three types of interoperability exist. They are:

1. **Institutional** (contractual) - involves financial agreements and contractual relationships (such as Memorandums of Understanding) between operators with interoperable systems.
2. **Procedural** - involves the adoption of common procedures and common data element definitions to allow the exchange of meaningful information.
3. **Technical** - involves the capability of equipment to communicate.

The 1997 Interoperability Workshop affirmed this definition and also observed that interoperability goes beyond the mere exchange of data. The data exchanged must be usable by the other system. Further, interoperability is extended to interchangeability when characterized by standardized interfaces and "plug and play" connectivity. The consequence of using standards that do not contribute positively to interoperability and interchangeability is—deployment of non-interoperable or non-interchangeable systems. The assessment and evaluation of contribution to interoperability and interchangeability will be based on: (1) quantitative and qualitative analysis and detailed examination of the consistency of the physical and logical characteristics of any external interfaces, (2) analysis of the standards, and (3) detailed examination of the syntactic and semantic content exchanged across those interfaces.

It should also be noted that interoperability is a prerequisite to interchangeability. That is, systems that are interoperable can then also be interchangeable or non-interchangeable. However, systems that are non-interoperable cannot then be interchangeable.

For purposes of this testing process and as stated above, the definition of interoperability is understood to be more encompassing than the standard interoperability definition of "the ability to use many different types of devices on the same communications channel". Clearly the point of the standards testing program is to assess, evaluate and report findings about more than just the ability of one device to not interfere with another device, and more than perfect interchangeability. Instead what the process is actually testing is that **the standards in fact do facilitate** the design, manufacture and operation of devices and subsystems that are interoperable and interchangeable, or that are interoperable with limited interchangeability.

In this assessment and evaluation of DMS and associated subsystems, limited interchangeability means that within the domain described by the six NTCIP standards, if all the DMSs perform the Core Functions identically, they will achieve the desired level of interoperability and interchangeability. They may then be fully interchangeable, interchangeable in a limited form, or not interchangeable. Through the remainder of this document the term interoperability and interchangeability is used to define this desired middle-of-the-road, interoperable and limited interchangeable condition."

Introduction: The "-ilities"

The "-ilities" is a term borrowed from the folklore of systems testing in the Department of Defense. In software engineering and quality assurance references, these elements are often referred to as "quality factors". These elements are intended to represent those less tangible yet measurable qualitative aspects of a test item that represent the foundations for a successful life-cycle—from cradle to grave. It has been implicitly and explicitly proven that the positive effects of the "-ilities" are essential yet not sufficient to ensure project, life-cycle and operational mission success.

The table included as Tab A enumerates and offers the criteria and relevance rationale for several of these "quality factors". The criteria are offered in the context of how it is suggested that the standard should be evaluated against the element. The rationale offers a reason for how it is

suggested that the element contributes or detracts from a successful product life-cycle and is therefore of value in testing, assessment and evaluation.

Mapping: "-ilities" to Assessment and Evaluation Categories

These three top-level categories are mapped, or decomposed, into their component "-ilities" as proposed in Table 1. These component "-ilities" are further defined in the table included as Tab A to this report.

Table 1: Categories and "-ilities" Cross-Reference

Element maps to > >	Suitability	Effectiveness	Interoperability/ Interchangeability
Compatibility		X	X
Completeness	X	X	X
Consistency	X	X	X
Correctness		X	X
Efficiency	X	X	
Productivity		X	
Simplicity	X	X	
Testability			X
Unambiguous		X	X
Usability	X	X	

This mapping states the proposition that the positive or negative effects of findings related to the "-ilites" are directly transferred to the stated category. The rationale statements in Tab A further cross-reference in support of this assertion. For example, in the "Compatibility" row, Table 1 makes the assertion that if a standard is "incompatible with its predecessors, peers and successors,"[5] then this will have a negative effect on both effectiveness (e.g., the vendor has to "solve" the incompatibility with a workaround) and interoperability/interchangeability (e.g., the vendor's workaround may not produce an interoperable/interchangeable solution).

Testing Process Outline

This section presents the outline and steps of the Test Process followed in the conduct of the ITS Standards Testing Program for NTCIP DMS at ISTHA. Also mentioned are any higher-level information gathering conditions such as dates, places, etc., related to the actual conduct of the process—but not the results or findings of the process.

5 By the definition of "Compatibility" offered in Tab A.

The original standards test planning effort included a concept for what data and information would be identified and collected, and where and how that collection would be accomplished. This then resulted in an estimate of the percentage of effort/earned value that was expected from each proposed approach. These estimates were:

1. Interview Product Vendor/Developer (40%)
2. Establish and Verify Standards Content Baseline (10%)
3. Establish Purity of External Interfaces (10%)
4. Execute Standards Test Trials (40%)

This describes the 100% higher-level test plan that was then conducted in pre-test, interview, analysis and on-site phases.

Pre-Test Knowledge Acquisition

The initial site screening, site visit, selection interview and MOU process with ISTHA identified several opportunities for pre-test information acquisition about ISTHA specifics, and about the anticipated NTCIP DMS domain. These opportunities for pre-test collection included discussion of, or review of documents reporting on:

1. The completion of system acceptance testing—both subsystems passed.
2. The conduct of initial subsystem interoperability/interchangeability testing (i.e., each vendor's control software suite was required to control and operate the other vendor's DMS)—which resulted in limited success with exceptions. It was stated in general that the vendors attribute these exceptions to their specific interpretation of NTCIP standards generalities or ambiguities—which (apparently in this case) manifests as a deviation from the expected results contained in the test procedures.
3. Review of the ISTHA DMS Subsystem Design Specification[6].
4. Attendance at the ISTHA Operator Training courses for one vendor's product.
5. Attendance at the ISTHA Maintenance Training courses for one vendor's product.

And in this same time frame, the test team had the opportunity to witness separate NTCIP DMS testing:

6. Observation/Participation in INCH/Enterprise NTCIP DMS subsystem compliance testing using the NTCIP Exerciser at WSDOT, NW Region in Seattle, WA (December 6-7, 1999).

The pre-test discussion, and site and subsystem specific information enabled the preparation of a structured interview worksheet (Tab B) that was used in the conduct of DMS vendor interviews.

6 … need the reference for this document.

Interview Product Vendor/Developer (40%)

This step in the testing process was intended to obtain approximately 40% of the qualitative data and information required for the assessment and evaluation of the NTCIP standards. The structured interview was targeted to address at least three potential categories of issues:

1. Issues related to exceptional conditions discovered by the vendor/developer,
2. Subjective/qualitative coverage and data collection for assessment of non-testable technical features, and
3. Initial verification of standards content baseline prior to the commitment of resources to the more specific and extensive planning and conduct of field testing.

The test team requested, collected, researched, examined and analyzed information provided by ISTHA, Daktronics and Vultron to establish a baseline understanding of standards content and foundation. Then technical interviews, discussions and facility tours were conducted at the vendor/contractor facilities. The Vultron interview was conducted at their facility in Rochester Hills, MI on November 12th, 1999. The Daktronics interview and tour was conducted at their facility in Brookings, SD on November 15th, 1999.

The expectation for the outcome of these interviews is that the vendor/developers will respond positively to the majority of the questions and issues related to their use of these specific standards for the deployment in Illinois. The test team then solicited their comments on exceptional conditions from their use of the standards in the specific case for ISTHA and in general. Their responses to the structured questionnaire, and induced follow-on discussion then guided the test team in the final tailoring of the ISTHA detailed test plans and procedures. Their normal answers (e.g., there are no issues in that area of the standard) were considered as a basis to reduce the density and coverage of features testing through the use of random sampling. The exceptional answers were used to guide the development of a more thorough approach to address those affected and specifically highlighted features of the standards.

The complete set of vendor responses to these questions is contained in Volume 3. Specific comments that resulted in findings are included in this report—these are reported as Interview Comments (IC) findings below.

Establish and Verify Standards Content Baseline (10%)

Together with the vendor/developer interview, this step in the process supplements the baseline knowledge of the standards content an additional 10%. It is an essential step to ensure a sufficient and rich standards content baseline that contributes to the decision to proceed with full test planning and conduct.

The test team qualitatively and quantitatively verified the degree of the use and consistency with the six standards of interest. This process included a pre-test examination and analysis of the six standards, and the static examination of ISTHA and vendor provided technical documentation. The test team obtained the Simple Network Management Protocol (SNMP) Management Information Base (MIB) files from both vendor/developers. These files were examined, compiled and all exceptions or unexpected results were recorded. It was further intended that source code structures

derived from these same standards and MIBs would be examined, but for proprietary reasons, these were not available to the test team.

It should be noted that only those aspects of the standards that specifically apply to DMS subsystems and/or NTCIP devices were evaluated. In cases where these six standards included by reference other commercial, national or international standards, or Internet RFC not directly related to NTCIP DMS, no examination of those referenced standards was undertaken.

There were several findings related to this analysis—these are reported as Analysis of Standards (AS) findings below.

Establish Purity of External Interfaces (10%)

This step in the testing process was designed to add another 10% to the accumulated body of test results knowledge. It was conducted on site at ISTHA as it required access to, and execution of, the functional NTCIP DMS subsystem. The pre-test installation of instrumentation was performed by the test team assisted by ISTHA site communications engineering personnel. This process verified the basic functional connectivity and test readiness of the DMS subsystem test items, and the non-interference of the instrumentation package.

The test team examined and tested the external interfaces to determine that all communications and protocols used were consistent with the use of the six NTCIP standards under test noting all observations and results. This step examines the interface using "Sniffer" technologies with data logging to ensure that all packets exchanged are proper NTCIP structures in terms of syntax and semantic content, and that there is no unexplained communications activity on the interface.

This step proved to be an important confidence builder in that it was a successful test of the lower-level technical aspects of the physical interfaces. This served to reduce risk and eliminate distractions prior to system-level usage.

These findings occurred on site and are included and reported as Test Results (TR) findings below.

Execute Standards Test Trials (40%)

This is the most important and dominant time phase of the test conduct. It completes the test result body of knowledge with a contribution of the final 40%. The ISTHA NTCIP DMS test plan was comprised of three components, each with planned test trials and steps:

1. **Core Functions** – these are the functions that should be assumed as the baseline for all NTCIP DMS. They were defined and developed in consensus with Standards Development Organizations (SDO's), vendor/developers, and DMS customers. These Core Functions are:

NTCIP DMS Core Functions

Control Sign Display Functions
Display a message on a sign Blank a sign

Create a Message Functions
Build a new message Delete a message New line New page Flash message Justify line Justify page Select Font
Exceptional Sign Control Functions
Default display condition following end of message
Scheduled Control Functions
Configure time-base schedule Configure day plan Configure action table Run the schedule
Monitor Sign Display Status Functions
Adjust display brightness View active message Detect pixel errors Identify source of message

1. **Normal (Product) Features** – over and above the Core Features, these are additional features and capabilities of the products deployed at ISTHA. These were included and "tested" to complete the test results body of knowledge from two perspectives: the DMS technology functional domain, and the potential for discovery of additional unexpected exceptional conditions.

2. **Exceptions** – these exceptions were derived from vendor interviews and from testing of Core and Product functions. The vendors identified areas in the standards where ambiguity or a lack of clarity required interpretation. These areas were exceptional conditions that required dedicated testing to determine any potential effects on suitability, effectiveness or interoperability/interchangeability. Additionally, any exceptional conditions noted during Core or Product testing, and a random sampling of other relevant lower order standards (e.g., 1101, 2001, 2301 and 2101) were included in this more detailed testing approach.

There were several findings related to the observations and results from the conduct of the on-site tests—these are included and reported as Test Results (TR) findings below.

Test Data Collection and Instrumentation

This section highlights the data collection and instrumentation tools and conditions utilized during NTCIP DMS testing at ISTHA.

Data Collection

The onsite data collection was accomplished using a variety of pre-planned and ad hoc methodologies, these included:

1. A **Tester Database** – this is a Microsoft Access database that includes the customized test procedures organized into test Sessions, Trials and Steps. It allowed the "Test Operator" to step through the selected test steps in an organized fashion, and provided for quick date-time stamped entry of test observations and results. With the proprietary exception noted earlier, this database is made available separately in ISTHA DMS test report Volume 3 (R-ISTHA-DMS-V3-0).

2. ***ComProbe™*** Data – this is a series of files produced by the instrumentation and data capture software that was used to examine and observe the external interface during testing. This data has been examined and the results of that analysis are included in this report as on-site TR findings.

3. **NTCIP Exerciser Log** – when the NTCIP Exerciser was utilized, and the test observations indicated an exceptional or unexpected result, the exerciser "Log" files were saved for later analysis. There were no findings resulting from this analysis..

Once on site, it was decided to routinely capture all screens involved in the testing of Core, Product and Exceptions testing. It was also decided to capture example screen displays during the use of the ***ComProbe™*** and *NTCIP Exerciser* tools. These would provide good supporting evidence should any exceptional conditions arise and require subsequent review offsite. Thus, the following additional information was collected:

4. **Power Point** Captures – graphical screen shots for all the tests/steps of each major step in the core and product test; as well as more detailed screen shots for exceptional observations, conditions and results using the vendor products, NTCIP Exerciser and data logging tools. With the same proprietary limitation, these PowerPoint files are included in Volume 3.

Test Instrumentation

The test team utilized a proven software reference implementation and a test tool instrumentation package during NTCIP DMS test conduct at ISTHA, respectively, these were:

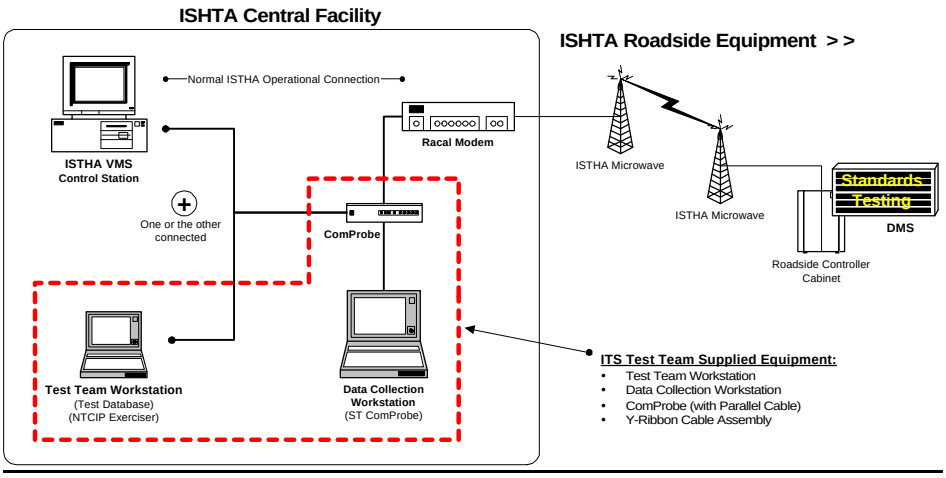
1. NTCIP Exerciser Version 3.5b, and
2. ComProbe™ TD115V hardware and software connected inline using a serial port Y-connector manufactured by Frontline Test Systems.

Figure 4 illustrates the control and instrumentation package deployed in support of the ISTHA on-site testing. The figure shows that the "Normal ISTHA Operational Connection" was replaced by

the insertion of a Y-cable and ComProbe hardware. This provided the connect point for the Data Collection Workstation to examine and capture the NTCIP DMS data packets on a non-interference basis with normal center-to-field communications operations. The several testing configurations required either the ISTHA VMS Control Station or the Test Team Workstation to be connected to the ISTHA roadside system, but never both simultaneously.

The ComProbe™ (TD115V) software and Breakout Box (SAM-232 Compact) were obtained from SerialTest and Black Box, respectively. This "sniffer" configuration was used to monitor, visually examine and collect data from the serial interface used to control and operate the ISTHA DMS roadside equipment during certain portions of the Core, Product and Exceptions testing. This combined test driver and data collection configuration is shown in Figure 4.

Figure 4: NTCIP Exerciser and/or Data Logger Test Configuration at ISTHA



Data Analysis

The variety of data and information collected during the conduct of this testing process were examined and analyzed in the following ways:

Vendor Interview

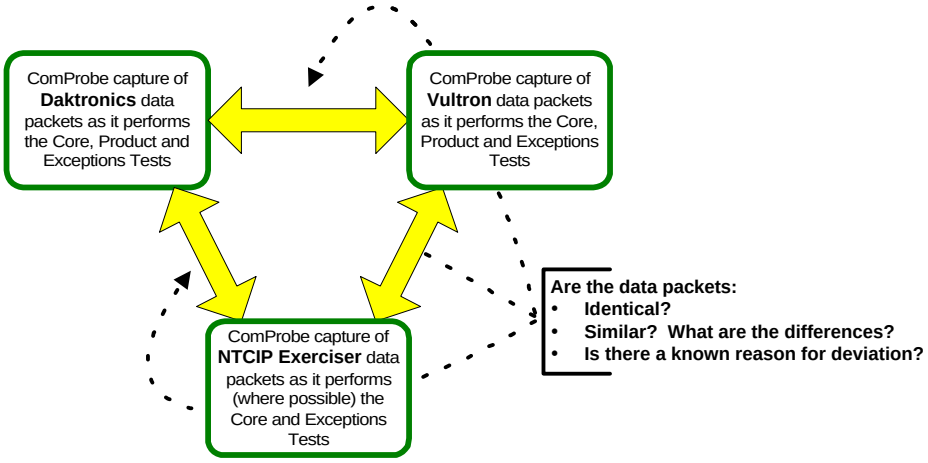
The vendor responses to the questionnaire and follow-on discussions were reviewed, assessed and evaluated in the preparation of findings. In the case of interviews, the test team probed for any issues related to suitability, effectiveness and contribution to interoperability/interchangeability by the standards used. Where the vendors raised those issues, the test team then probed for necessary detail to determine if a finding was appropriate, and/or if an exceptional test case would be constructed. If an issue traced to an appropriate "-ility", then an IC (Interview Comments) finding was developed. If no issues were raised during the interview and follow-up discussion, then no findings resulted.

Test Results

The test team recorded all test observations and results in the tester database, in logs and on flip charts. These items were then reduced, examined, analyzed and evaluated to see if the content warranted a finding.

The packets of data flow across the interface from the ISTHA Central and the roadside DMS subsystem were examined and analyzed. The goal of this analysis was to discover any exceptional conditions or anomalies that trace to the one or more of the six standards under examination. The packets related to each specific action occurring during Core, Product and Exceptions testing, for each vendor control software and the NTCIP Exerciser were compared in pair-wise fashion to see if they were similar, identical, or if not, that the differences were explained and acceptable. This comparison and thought process is illustrated in Figure 5.

Figure 5: Examination of Interface Data Packets



These results of this packet comparison and analysis are included later in this report, and the files including the detail of all collected packets are available in Volume 3.

In observation, result or packet comparison cases where an unexplained anomaly was discovered, or a known exception proved true, a finding was developed to capture that standards-related situation. These are then reported here as TR (Test Results) findings.

Analysis of Standards

The test team thoroughly examined the six standards in great detail as part of the preparation of the test steps enumerated in Tab C. This examination included a detailed read, a search for consistency, completeness, compatibility, etc. (e.g., the "-ilites") in the standards, and an analysis and evaluation of any issues or concerns discovered. This analysis also included detailed pre-test examination, analysis and evaluation of the MIBs associated with the six NTCIP standards under test. This step in the process was referred to as static analysis. The findings resulting from this assessment and evaluation are reported as AS (Analysis of Standards) findings in this report.

Observations, Results and Findings

This section presents the test findings as items derived and determined from examination, interpretation and analysis of all test data and information.

It should be reiterated that both vendors developed and deployed functional NTCIP DMS subsystems at ISTHA. The statements of findings that follow apply directly to the standards used to create these two operational NTCIP DMS subsystems.

Terminology

This section introduces several terms and phrases that will be used to provide commentary on the Effect and Severity of the findings resulting from this test, and the implied urgency of the "Action" needed to resolve. These statements of effect, severity, and action are the result of data analysis and are the solely the judgment and opinion of the test team analyst/evaluator.

The terms or icons used to describe "Effects" will be:

- **(+)** **A positive** effect; this observation indicates that the associated item has a positive effect on the domain of interest.
- **(0)** **A neutral** effect; this observation indicates that the associated item as observed has a neutral effect on the domain of interest; but, could be positive or negative depending on related implementation factors.
- **(-)** **A negative** effect; this observation indicates that the associated item has a negative effect on the domain of interest.

The terms used to describe "Severity" are derived from IEEE software standards (e.g., *IEEE Std 1044-1993*, p. 21, Table 7d) as interpreted for our use below.

Our Terms	IEEE Term	Meaning
Critical	*Urgent*	Prevents completion of mission (task) or jeopardizes personal safety
Serious	*High*	Adversely affects completion of mission (task), no workaround solution exists
Major	*Medium*	Adversely affects completion of mission (task), workaround solution exists
Minor	*Low*	Inconvenience or annoyance
Cosmetic	*None*	None of the above

Given these terms as defined, Table 2 illustrates them in combination and associated with the test team definitions and recommendations associated with each pair-wise selection of "Effect/Severity" => "Impact" on the NTCIP DMS community as a domain. The urgency then associated with the "Action" to resolve is often implicit and is stated within each corresponding cell of the table. By the very nature of this, or any testing process, the search is for negative impact exceptions; thus, these will dominate the reporting process as they are of more interest in assessment and evaluation of the standards (i.e., a positive column is not included in the table).

Table 2: Terminology Used in Findings

	Negative (-)	Neutral (0)
Critical	A mission critical showstopper. A standard flawed to this degree shall be corrected; immediate solution and amendment delivered by industry bulletin is strongly suggested.	Potential for a critical showstopper but dependent on other implementation unique factors. A standard flawed to this degree shall be corrected; immediate amendment by industry bulletin is strongly suggested.
Serious	A significant impediment with no workaround. A standard deficient to this degree shall be corrected; immediate amendment by industry bulletin is suggested.	Potential for a significant impediment with no workaround but dependent on other implementation unique factors. A standard deficient to this degree shall be corrected; immediate amendment by industry bulletin is suggested.
Major	A significant problem but with a workaround. A standard deficient to this degree should be corrected; near term amendment is suggested.	Potential for a significant problem but with a workaround and dependent on other implementation unique factors. A standard deficient to this degree should be corrected; near term amendment is suggested.
Minor	An inconvenience or annoyance. The standard should be corrected; action in the normal course of periodic review and update is suggested.	Potential inconvenience or annoyance. The standard should be corrected; action in the normal course of periodic review and update is suggested.

Interview Comments (IC)

The items identified as "IC-#" are derived from the assessment and evaluation of comments and discussion stimulated by the general questionnaire and interview conducted by the test team at both the vendor locations. The general questionnaire that was used for the interview is included in this report as Tab B. These findings are not intended to, and do not specifically state each vendor's viewpoint, rather these comments highlight the general and specific standards anomalies they collectively experienced during the life-cycle process in development and deployment of an operational product using NTCIP DMS standards.

Test Results (TR)

The items identified as "TR-#" describe the findings derived during on-site tests, test observations and data capture at ISTHA. They include test comments based on observations and results recorded in the Tester (MS Access) Database during the test. These remarks also include the analysis of the ComProbe data, exceptions that were raised from vendors and subsequently tested, and finally, any other observations made by the test team while conducting the trials on Core, Product and Exceptions test trials.

The Core Functions, which are proposed as the essence of all DMSs, were initially identified by the NTCIP Joint Committee and the test team working in cooperation. These core functions were treated as the required functional baseline for the creation of interoperability/interchangeability of standards test procedures. This approach enables the test design for testing, analysis, assessment and evaluation of the degree of interoperability/interchangeability of the NTCIP DMS subsystems as clearly stated in the following hypothesis:

H_0: NTCIP DMS subsystems are interoperable/interchangeable for all Core Functions.

In other words, the standards shall enable NTCIP DMS subsystems to be interoperable/interchangeable for all core functions. The test team conducted all tests for the core functions. All observations, results and data packets exchanged were recorded, captured, examined and analyzed. There were over 3,000 data packets captured and examined. Of these, only 8% indicated any interesting anomalies—4% (137) indicated deviations from standards that "may" inhibit or preclude interoperability/interchangeability, another 4% (139) indicated deviations that "will" preclude interoperability/interchangeability. These issues are included in the TR and AS findings to follow.

Results from Analysis of Standards (AS)

The items identified as "AS-#" are derived from the assessment and evaluation of the standards and their supporting MIBs. These findings are not intended to be an exhaustive nor complete review of the standards since only those portions relevant to NTCIP DMS were closely examined. These findings and comments highlight the general and specific standards anomalies that the test team analyst discovered during the review and preparation of other testing materials.

Findings: Interview Comments (IC)

IC-1: Global Local Time

Discussion: Both vendors stated that they had problems with Global Time. It was not tied to a particular time zone. A subsequent amendment added a Global Local Time object that remedied the problem for the most part. A residual issue is that under some circumstances (day light saving time), one could SET a time and GET a time so the values would not match. One vendor chose to implement a Global Time DST Differential. Both sought guidance on daylight savings time objects and subsequently, both choose to implement the Amendment to 1201 Global Object Definitions (TS 3.4) that contained updates to the globalTime objects. There was some project and technical risk in doing this since at that time, the referenced amendment was still in DRAFT status.

Effect/Severity: (0) Minor/Completeness

Reference: see TR-2 for overall conclusion and recommendation.

IC-2: Scheduler

Discussion: Both vendors expressed great displeasure with the Scheduler object. They stated that there is a problem with the override of a scheduler task without clearing the scheduler table. There is no global mechanism to enable or disable the scheduler. Both vendors created custom objects to overcome this issue.

Effect/Severity: (-) Major/Completeness, (-) Major/Efficiency

Reference: see TR-1 for overall conclusion and recommendation.

IC-3: Power Supply

Discussion: The standards provide for a single power supply on a sign. DMS signs have multiple power supplies and these are not addressed. The solutions implemented by the vendors were dissimilar: one deciding in favor of custom objects, the other using the Auxiliary I/O definitions in the higher-order standard (e.g., Global Object Definitions) which provides for analog and digital I/O ports but does not specify exact use. This omission by the standard leads manufacturers to come up with different implementations.

Effect/Severity: (-) Major/Completeness, (-) Minor/Unambiguous,
(-) Major/Usability

Reference: see TR-4 for overall conclusion and recommendation.

IC-4: Multiple Light Sensors

Discussion: Similarly, the DMS standards provide for only one photocell (i.e., an ambient light sensor). Both vendors were required to implement three of these illumination sensors as required in the ISTHA Request for Proposal (RFP). They also mentioned the fact that virtually all RFPs will require multiple sensors. The solutions implemented by the vendors were dissimilar: one approach taken was to create custom objects, the other approach was to use the Auxiliary I/O definitions in the higher-order standard (e.g., Global Object Definitions) which provides for analog and digital I/O ports but does not specify exact use. This omission by the standard leads manufacturers to come up with different implementations.

Effect/Severity: (-) Major/Completeness, (-) Minor/Unambiguous,
(-) Major/Usability

Reference: see TR-3 for overall conclusion and recommendation.

IC-5: No Capability to do Graphics

Discussion: Both vendors commented that another stated shortcoming in the standard was that there is no capability to do graphics.

Effect/Severity: (-) Minor/Completeness

Conclusion: The ability to do graphics would be an extended, nice to have feature for more general use of DMS, but it is not a required core function.

Recommendation: No action.

IC-6: Lack of Communications to obtain Guidance on NTCIP Standards

Discussion: A general comment that was raised by both vendors was that there needed to be a better communications channel for obtaining information on the NTCIP standards, submitting comments and suggestions related to the standards, and obtaining help on their usage. Additionally, they found it difficult to obtain information related to referenced standards such as those developed by ISO.

Effect/Severity: (0) Major/Simplicity

Conclusion: This is a programmatic or systemic issue not related to standards themselves.

Recommendation: Better inform users on the process for obtaining help on standards usage, and for submission of comments and suggestions.

Findings: Test Results (TR)

TR-1: Scheduler Object

Upon analysis of the core functions captured data, the standard had deviations related to DMS scheduler functionality. There were 138 discrepancies out of a total of 3,049 data packets that were analyzed.

The 1203 standard (DMS objects) currently defines the following scheduling action objects:

```
--2.9.1.1.1.1         Action Table Entries Parameter
--2.9.1.1.1.2         Action Table Parameter
--2.9.1.1.1.2.1       Action Index Parameter
--2.9.1.1.1.2.2       Action Message Code Parameter
```

The 1201 standard (Global objects) currently defines the following scheduling action objects:

```
--2.4.3               TimeBase Event Scheduler Node
--2.4.3.1             Maximum Number of Time Base Schedule Entries Parameter
--2.4.3.2             Time Base Schedule Table
                      TimeBaseScheduleEntry
                      timeBaseScheduleNumber
                      timeBaseScheduleMonth
                      timeBaseScheduleDay
                      timeBaseScheduleDate
                      timeBaseScheduleDayPlan

--2.4.4.2      Maximum Number of Day Plan Events - Parameter
--2.4.4.3      Day Plan Table
                      TimeBaseDayPlanEntry
                      dayPlanNumber
                             dayPlanEventNumber
                             dayPlanHour
```

```
                                    dayPlanMinute
                                    dayPlanActionNumberOID

        --2.4.4.4       Day Plan Status Parameter
```

Discussion: As shown above, the scheduling action object is addressed under standard 1203 for some objects, and the rest are addressed under 1201 for global objects. During the interview process, both vendors identified that the scheduler related portions of the NTCIP - Object Definitions for Dynamic Message Signs (1203) standard were deficient. Both vendors sought additional guidance from NEMA related to this issue. The standards, though addressing most of the objects, do not define an object for enabling or disabling the scheduler. The solution to address the lack of this object and remain compliant with NTCIP standards was to create a custom object. See IC-2 for interview comments.

Effect/Severity: (-) Major/Completeness, (-) Major/Efficiency, (-) Major/Simplicity

Conclusion: Creation and use of one or more custom objects is a solution that works, but this clearly leads to a potential for interoperable but non-interchangeable DMS subsystems.

Recommendations:

1. The standards (both 1201 & 1203) need to be enhanced to include an object to enable and disable the scheduler.
2. A companion document that could serve as a users guide could be developed to assist the vendors in implementing the scheduler objects.

TR-2: Global Local Time Differential

In the standard 1201, Global Time is not tied to a particular time zone. A subsequent amendment to 1201 added a Global Local Time Differential object that remedied the problem for the most part.

The 1201 (TS 3.4) Amendment 1 (Draft) defines the Global Local Time Differential object as:

```
globalLocalTimeDifferential   OBJECT-TYPE
SYNTAX  INTEGER (-43200..43200)
ACCESS  read-write
STATUS  mandatory
DESCRIPTION    "Indicates the number of seconds offset between local time and GMT.
Positive values indicate local times in the Eastern Hemisphere up to the
International Date Line and negative values indicate local times in the Western
Hemisphere back to the International Date Line.  If one of the daylight savings times
is activated, this value will change automatically at the referenced time. For
example, Central Standard Time (CST) is -21600 and Central Daylight Time (CDT) is -
18000."
```

Discussion: Both the vendors tried to receive guidance on daylight savings time objects from the standards organizations and NEMA, then they both choose to implement the Amendment to 3.4 that contained updates to the `globalTime` objects (which was still in draft format). See IC-1 for interview comments.

Effect/Severity: (0) Minor/Completeness, (0) Minor/Usability

Conclusion: This situation has created confusion and introduced project risk through the use of a draft standard amendment that "solves a known problem".

Recommendations:

1. The process for publishing standards amendments should be expedited.
2. The SDOs should provide improved access for inquiries, and information to vendors who use these standards to inform them (the vendors) of changes.

TR-3: Support for Multiple Light Sensors

The applicable standards (1201, 1203) do not support multiple light sensors.

The 1203 standard (DMS objects) defines the following illumination related objects:

```
--2.8     ILLUMINATION/BRIGHTNESS OBJECTS

illum  OBJECT IDENTIFIER ::= {dms 7}
-- This node is an identifier used to group all objects supporting DMS sign
illumination functions that are common to DMS devices.

--2.8.1.1.1.1  Illumination Control Parameter
dmsIllumControl  OBJECT-TYPE
SYNTAX    INTEGER {
               other (1),
               photocell (2),
               timer (3),
               manual (4)
               }
ACCESS    read-write
STATUS    mandatory
DESCRIPTION "Indicates the method used to select the Brightness Level.
Photocell indicates that the Brightness Level is based on photocell status.
Timer indicates the the Brightness Level is set by an internal timer.  Manual
indicates that the Brightness Level must be changed via the dmsIllumManLevel-
object.  When switching to manual mode from any other mode, the current
brightness level shall automatically be loaded into the dmsIllumManLevel
object."
```

```
::= {illum 1}


--2.8.1.1.1.2  Maximum Illumination Photocell Level Parameter
dmsIllumMaxPhotocellLevel   OBJECT-TYPE
SYNTAX    INTEGER (0..65535)
ACCESS    read-only
STATUS    mandatory
DESCRIPTION "Indicates the maximum value given by the
dmsIllumPhotocellLevelStatus-object."
::= {illum 2}


--2.8.1.1.1.3  Status of Illumination Photocell Level Parameter
dmsIllumPhotocellLevelStatus   OBJECT-TYPE
SYNTAX    INTEGER (0..65535)
ACCESS    read-only
STATUS    mandatory
DESCRIPTION "Indicates the level of Ambient Light as a value ranging from 0
(darkest) to the value of dmsIllumMaxPhotocellLevel- object (brightest), based
on the photocell detection."
::= {illum 3}
```

Discussion: As shown above, the standard provides suitable access for DMS technology using no more than one illumination photocell. There are at least three compliant yet often divergent interpretations or solutions to this omission or limitation by the standards: (1) use only one light sensor, (2) creation and use of custom objects, or (3) use of alternative objects in the standard. Generally:

1. The use of only one light sensor is unreasonable given that most of the RFPs for DMS state the requirement for multiple (usually 3) light sensors.
2. The creation and use of custom objects is a solution that works but this clearly leads to a situation of interoperable but non-interchangeable subsystems.
3. The use of more general purpose objects, for example, 1203 (DMS Objects) includes analog and digital I/O ports that can be addressed as individual objects (e.g., `analogIOPort.X`, `digitalIOPort.X`). The use of these objects to acquire status and manage "analog" and "digital" subassemblies and components is, on one hand, innovative yet again, divergent from interoperability/interchangeability of DMS subsystems.

See IC-3 for interview comments.

Effect/Severity: (-) Major/Completeness, (-) Minor/Unambiguous, (-) Major/Usability

Conclusion: This lack of support for multiple illumination sensors leads to a multiplicity of interpretations including the creation and use of custom objects, innovative yet divergent use of higher-order standards, and the potential future use of other compliant or non-compliant proprietary techniques. Therefore, multiple illumination sensors must be supported in the standards.

Recommendations:

1. The standard should be modified to include coverage of one or more illumination brightness sensors. In the style of the existing objects, this might take the form:

```
[ maxDMSIllumControls, numDMSIllumControls ]
dmsIllumControl.X
dmsIllumMaxPhotocellLevel.X
dmsIllumPhotocellLevelStatus.X
```

where `maxDMSIllumControls` and `numDMSIllumControls` objects could indicate the maximum number and number of currently installed or active sensors, respectively; the "X" then indicates available access to a specific table object within that scope.

2. The 1203 (DMS) standard could be modified to recommend that this situation be implemented by using the analog or digital I/O ports described elsewhere in 1203. However, this solution still leaves room for vendor interpretation leading to interoperable but non-interchangeable subsystems.

3. A companion document (e.g., 1201, 1203 DMS NTCIP User's Guide) could be developed to guide the vendor and application developers.

TR-4: Support for Multiple Power Supplies

The applicable standards (1201, 1203) do not support multiple power supplies.

The 1203 standard (DMS objects) defines the following power related objects:

```
--2.11.3  Power Status Objects
statPower  OBJECT IDENTIFIER ::= {dmsStatus 8}
-- This node is an identifier used to group all objects supporting DMS sign
-- power status monitoring functions that are common to DMS devices.


--2.11.3.1.1.1 Sign Volts Parameter
signVolts OBJECT-TYPE
SYNTAX    INTEGER (0..65535)
ACCESS    read-only
STATUS    optional
DESCRIPTION "A voltage measurement in units of hundredth (1/100) of a volt.  The
maximum value (0xFFFF) corresponds to a voltage of 655.35 volts.  This is an
indication of the sign battery voltage."
::= {statPower 1}


--2.11.3.1.1.2 Low Fuel Threshold Parameter
lowFuelThreshold OBJECT-TYPE
SYNTAX    INTEGER (0..255)
ACCESS    read-write
STATUS    optional
DESCRIPTION "Indicates the low fuel level threshold used to alert the user.  The
threshold is indicated as a percent (%) of a full tank.  When the level of fuel
is below the threshold, the bit for power alarm (bit 2) in the shortErrorStatus-
object shall be set to one (1)."
::= {statPower 2}


--2.11.3.1.1.3 Fuel Level Parameter
fuelLevel OBJECT-TYPE
SYNTAX    INTEGER (0..100)
ACCESS    read-only
STATUS    optional
DESCRIPTION "A number indicating the amount of fuel remaining, specified as a
percent (%) of a full tank."
```

```
::= {statPower 3}


--2.11.3.1.1.4 Engine RPM Parameter
engineRPM OBJECT-TYPE
SYNTAX    INTEGER (0..255)
ACCESS    read-only
STATUS    optional
DESCRIPTION "Indicates the engine rpm in units of 100.  This provides a range
from 0 rpm to 25500 rpm."
::= {statPower 4}


--2.11.3.1.1.5 Line Volts Parameter
lineVolts OBJECT-TYPE
SYNTAX    INTEGER (0..255)
ACCESS    read-only
STATUS    optional
DESCRIPTION "The DMS line voltage measurement in (1.0) volts.  The range is 0
volts to 255 volts."
::= {statPower 5}


--2.11.3.1.1.6 Power Source Parameter
powerSource OBJECT-TYPE
SYNTAX    INTEGER {
                other (1),
                powerShutdown (2),
                noSignPower (3),
                acLine (4),
                generator (5),
                solar (6),
                battery (7)
                }
ACCESS    read-only
STATUS    mandatory
DESCRIPTION "Indicates the source of power that is currently utilized by the
sign."
--other: indicates that the sign is powered by a method not listed below (see
--device manual);
--powerShutdown: indicates that there is just enough power to perform shutdown
--activities.
--noSignPower: indicates that the sign controller has power but the sign display
--has no power;
--acLine: indicates that the controller and sign is powered by AC power;
--generator: indicates that the sign and the controller are powered by a
--generator;
--solar: indcates that the sign and the controller are powered by solar
--equipment;
--battery: indicates that the sign and controller are powered by battery with no
--significant charging occurring.
::= {statPower 6}
```

Discussion: As shown above, the standard provides rather limited coverage of what appears to be a fossil-fueled, rotating-engine powered DMS; with limited access to potentially useable features like line voltage and sign voltage and no access to useful status information. At best, with atypical interpretation and usage, it provides access to a DMS technology using no more than one power supply. There are at least three compliant yet often divergent interpretations or solutions to this omission or limitation by the standards: (1) use only one power supply, (2) creation and use of custom objects, or (3) use of alternative objects in the standard. The following discussion applies and has been de-identified as to any specific vendor or implementation.

(1) The use of only one power supply is unwise and unreasonable given that most DMS would require robust and redundant power to both digital and analog circuitry in the

sign(s) and the accompanying control cabinetry, and for power to sign heaters and fans in some applications.

(2) The creation and use of custom objects is a solution that works but this clearly leads to a situation of interoperable but non-interchangeable subsystems.

(3) The use of a more general object; for example, 1203 (DMS Objects) includes analog and digital I/O ports that can be addressed as individual objects (e.g., `analogIOPort.X`, `digitalIOPort.X`). The use of these objects to acquire status and manage "analog" and "digital" power supplies as subassemblies and components is, on one hand, innovative yet again, divergent from interoperability/interchangeability of DMS subsystems.

See IC-4 for interview comments.

Effect/Severity: (-) Major/Completeness, (-) Minor/Unambiguous, (-) Major/Usability

Conclusion: This lack of support for multiple power supplies leads to a multiplicity of interpretations including the creation and use of custom objects, innovative yet divergent use of higher-order standards, and the potential future use of other compliant or non-compliant proprietary techniques. The root cause for these functional yet divergent interpretations lies in the current standard specification. Therefore, it is reasonable to expect that the standard support multiple power sources.

Recommendations:

1. The standard should be modified to include coverage of one or more power supplies. In the style of the existing objects, this might take the form:

```
[ maxPowerSources, numPowerSources ]
dmsPowerSourceType.X (1)
dmsPowerSourceStatus.X (2)
dmsPowerSourceActivate.X
```

   where `maxPowerSources` and `numPowerSources` objects could indicate the maximum number and number of currently installed or active power sources, respectively; the “X” then indicates available access to a specific table object within that scope. Note: (1) could provide an enumerated list of power supply types as an extension of that shown for `powerSource` in the existing standard, and (2) could provide access to a double-indexed table item allowing a level of sophistication in sampling power supply status (e.g., `powerSourceStatus.n.m` representing power supply “n”, status item “m”).

2. The 1203 (DMS) standard could be modified to recommend that this situation be implemented by using the analog or digital I/O ports described elsewhere in 1203. However, this solution still leaves room for vendor interpretation leading to interoperable but non-interchangeable subsystems.

3. A companion document (e.g., 1201, 1203 DMS NTCIP User's Guide) could be developed to guide the vendor and application developers.

TR-5: Illumination Brightness

While conducting the data analysis for the tests related to the dmsIllumBrightnessValues object, it was discovered that a varied approach to defining the brightness levels existed between the vendors. The standard indicates that a range defined by the entities known as photocell level down and photocell level up define each brightness level. These entities are a function of the sign's photocell detection of ambient light.

The 1203 standard (DMS objects defines the `dmsIllumBrightnessValues` object as:

```
--2.8.1.1.1.7  Illumination Brightness Values Parameter
dmsIllumBrightnessValues  OBJECT-TYPE
SYNTAX   OCTET STRING
ACCESS   read-write
STATUS   mandatory
DESCRIPTION "An OCTET STRING describing the sign's Brightness Level in
relationship to the Photocell(s) detection of ambient light.  For each
brightness level, there is a corresponding range of photocell levels.  The
number of levels transmitted is defined by the first byte of the datapacket, but
cannot exceed the value of the dmsIllumNumBrightLevels object. "
--After a SET, an implementation may interpolate these entries to create a table
--with as many entries as needed.  For each level, there are three 16-bit values
--that occur in the following order:
--Brightness point, Photocell level down, Photocell level up.
--The Brightness point is a value between 0 (no light output) and 65535 (maximum
--light output).
--Each step is 1/65535 of the maximum light output (linear scale).
--The Photocell-level-down is the lowest photocell level for this brightness
--level.  Should the photocell level go below this point, the automatic
--brightness level would go down one level.
--The Photocell-level-up is the highest photocell level for this brightness
--level.  Should the photocell level go above this point, the automatic
--brightness level would go up one level.
--The photocell level (Up and Down) values may not exceed the value of the
--dmsIllumMaxPhotocellLevel object."
::= {illum 7}

--The points transmitted should be selected so that there is no photocell level
--which does not have a brightness level.
--Hysteresis is possible by defining the photocell-level-up at a level higher
--than the upper level's photocell-level-down.
--The following provides an example of this operation
--  0                 1                 2                 3
--  0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
-- +-+-+-+-+-+-+-+-+
-- |NumEntries = n |
-- -+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
--       Brightness level 1       |  Photocell-Level-Down point 1   |
-- -+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
-- |   Photocell-Level-Up point 1       Brightness level 2          |
-- +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-
-- |   Photocell-Level-Down point 2 |   Photocell-Level-Up point 2
-- +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-
--
-- +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-
-- |   Photocell-Level-Down point n |   Photocell-Level-Up point n
-- +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-
```

Discussion: The number of levels defined by one vendor is twenty. The other vendor maintains 255 levels of brightness. One vendor uses sequential numbering of their brightness levels with non-overlapping sequential ranges for the photocell level down and photocell level up. The other vendor uses non-sequential brightness and photocell levels in conjunction with

a custom object to provide the intended functionality of the object. Neither vendor uses a linear scale as specified in the standard.

Effect/Severity: (-) Major/Consistency, (-) Minor/Simplicity, (-) Major/Unambiguous

Conclusion: The varied approach to the implementation of the `dmsIllumBrightnessValues` object may indicate that the standard could be improved to support different technologies from various vendors. While providing the ability to insert and utilize custom objects for a standards-compliant sign, to allow a manufacturer to support objects and technologies not well defined by the standard; the implementation of custom objects to supplement standardized objects leads to interoperability/ non-interchangeability. While this leads to non-interchangeability, a workaround does exist. Unfortunately, the workaround requires a detailed and comprehensive understanding of the vendor's technology and implementation. Additionally, manual calculations or conversions of one vendor's brightness level to another's is required to accurately set a vendor's sign with a control software package other than that supplied by the manufacturer. Typically, a percentage of maximum brightness is more easily understood by a control operator rather than a linear stepwise range.

Recommendation: Consider the implementation of objects that enable the setting of the brightness level, as well as recording the current level of brightness, as a percentage of the maximum illumination of the photocell.

TR-6: Message MultiString CRC

During the test it was discovered that the activation of a message on a vendor's sign is inextricably linked to the values of the beacon and pixel service objects associated with the message. The standard defines that the `dmsMessageCRC` value is the CRC-16 calculation of the message multistring, and the settings for beacons and pixel service. This important CRC value is used in activating messages as well as identifying messages for use by other objects. When a message is created and saved to the sign, the sign calculates the CRC and uses it to compare against the value sent when trying to activate a message. Thus, it is imperative that whenever a message is requested for display that the CRC value sent in the activation request and that stored in the sign are exact. Therefore, the state of the beacon and pixel service objects must be the same when activating a message as there were set when creating and storing the message or an error will occur and the message will not be displayed on the sign.

The 1203 standard (DMS objects) defines the `dmsMessageCRC` as:

```
--2.6.1.1.1.8.5     Message CRC Parameter
dmsMessageCRC   OBJECT-TYPE
SYNTAX    INTEGER(0..65535)
ACCESS    read-only
STATUS    mandatory
DESCRIPTION "Indicates the CRC-16 (polynominal defined in ISO/IEC 3309) value
created using the values of the dmsMessageMultiString- (MULTI-Message), the
```

```
dmsMessageBeacon-, and the dmsMessagePixelService -objects in the order listed,
not including the type or length fields."
::= {dmsMessageEntry 5}
```

Discussion: On-site analysis of the calculated message CRC, verified by subsequent analysis of the collected data packets, showed inconsistencies in the values used to set the beacon and pixel service objects. These inconsistencies were apparent when utilizing the vendor's control software to create, set, and activate messages. One vendor choose to set each of these objects to a default value of 0, indicating that the beacon and pixel service objects are to disabled. The setting of these objects with the other vendor's software package was unintuitive. Further investigation showed that enabling the pixel service object also enabled the beacon object. However, enabling the beacon object did not enable the pixel service object. Additionally, the vendor chose to use these two objects set to 1 (enabled) as the default condition.

Effect/Severity: (-) Minor/Compatibility, (-) Minor/Consistency, (-) Minor/Productivity, (-) Minor/Testability, (-) Minor/Unambiguous

Conclusion: The `dmsMessageCRC` value is extremely important in exercising a core function of the sign, displaying a message. Using an incorrect value for this object will result in an error being generated and the message will not be displayed on the sign. Each vendor chose to set the default value for these objects differently. Thus the user must remember the idiosyncrasies in displaying a message from one sign to the next.

Recommendations:

1. Emphasize the importance of identifying the default settings for the beacon and pixel service objects. Encourage each vendor to identify the default settings for these objects and the manner in which to change them.
2. Provide information to the user on the importance of the beacon and pixel service objects when activating a message. While this information should not be considered part of the base standard, it may improve the compatibility and usability of the products, if it were to be disseminated in a standard companion document such as a lessons learned or operational guide.

Findings: Analysis of Standard (AS)

AS-1: Maximum Temperature of Sign Housing Parameter

Upon analysis of the 1203 (TS 3.6) standard, it was discovered that this object's valid integer range is defined as 0-255. All of the remaining temperature objects in the Temperature Conformance Group have a valid integer range of -128 to +127.

The 1203 standard (DMS objects) defines the `tempMaxSignHousing` object as:

```
--2.11.4.1.1.6 Maximum Temperature of Sign Housing Parameter
tempMaxSignHousing OBJECT-TYPE
```

```
SYNTAX    INTEGER (0..255)
ACCESS    read-only
STATUS    optional
DESCRIPTION "Indicates the current temperature, single sensor, or the current
maximum temperature, multiple sensors in the sign housing in degrees Celsius."
::= {statTemp 6}
```

Discussion: The inability to set negative integer values for this object may impact the execution of actions when this object is used to compare against a threshold level. As implemented at ISTHA, this object does not perform in this capacity and is presumably used for reporting purposes only.

During the test and subsequent data analysis, it was discovered that the values for the minimum and maximum temperatures for related objects (i.e., `tempMinAmbient` and `tempMaxAmbient`) return the same value. This raises the question as to whether the temperature objects are used in a capacity other than reporting purposes, whether the vendor's have implemented them correctly, or whether they are functional.

Effect/Severity: (-) Major/Consistency

Conclusion: This discrepancy does not impact the core functionality of the sign. Since the objects do not appear to be used for purposes other than reporting, the impact is minimal as deployed and utilized. However, in the event that this object would be used to activate an action or log entry when a threshold is reached, an appropriate value range would become imperative.

Recommendations

1. Draft an amendment to the standard that corrects the valid range to –128 to +127.

AS-2: External Reference Consistency Issues

In ITS standards 1101, 2001, 2301 and 2101 (i.e., TS 3.2, 3.3, 3.STMF and 3.PMP232 resp.), a number of non-ITS standards have been used to define the operation and interaction of hardware and software components, systems, and articles related to Dynamic Message Signs. Standards from various bodies such as ISO, IEC, EIA, TIA, and IEEE define items such as timing, protocols, managed objects, and data packet structures used in the implementation of an NTCIP DMS subsystem.

Discussion: Use of non-ITS standards expedite the implementation of standardized DMS as many of these standards have been ratified and successfully deployed in operating environments for many years. These standards typically define the underlying data communications layers that enable control stations to configure and operate the DMS. However, in many cases information contained in these standards may be difficult to acquire and understand. Information from trustworthy sources can be limited, hard to find, and in some cases, difficult to acquire. For instance, ISO standards must be purchased and can be expensive. Additionally, the information contained within the standards may be difficult to

interpret. Items such as those listed below, that are defined in these standards, must be interpreted in the same manner in order to provide interoperability/interchangeability:

1. Group addressing
2. Short and long form length encodings for TLV (tag-length-value) data structures
3. BER/OER encoding rules
4. 2' s complement encoding
5. HDLC bit stuffing/transparency
6. CRC-16 calculation

Effect/Severity: (-) Major/Compatibility, (-) Major/Consistency

Conclusion: Use of "non-ITS" standards is desirable and contributes favorably to the definition, implementation, and interoperability/interchangeability of standards compliant DMS. However, the implementation of the concepts, functions, and services described in these standards could be more manageable if they were clearly understood and interpreted in a consistent fashion.

Recommendation: Maintain dialogue with vendors regarding problems interpreting and implementing "non-ITS" standards. If warranted, provide additional guidance or clarification to items contained within these standards. This information could be contained within a companion document to the standard.

AS-3: Network Layer

Analysis of the 2001 standard (Class B Profile) noted a discrepancy in defining the functions and services of the Network layer.

Discussion: Introductory text in Section 2.2.4 of the 2001 (TS 3.3) standard describes the general aspects of the Network Layer as being null or empty. However, Section 3.4 of the standard indicates that a minimal amount of functionality is required in the Network Layer and further specifies the characteristics of this functionality.

Effect/Severity: (0) Minor/Consistency

Conclusion: The standard details the data communication specifications of the lower layer protocols used in the Class B Profile. Many of these specifications are based on existing, well-implemented and understood standards that have been successfully deployed in production environments for many years. Therefore, while not paramount to the suitability, effectiveness, and interoperability/interchangeability of the standard, clarification of the intent of the services and functions of the Network layer functions may provide a more favorable impression of the standard and induce confidence in the standard and potentially, faster adoption by product vendors.

Recommendation: Conduct proceedings to draft an amendment to the base standard that clarifies the discussion of the Network Layer specifications.

AS-4: LAPB MIB Objects

Analysis of the 2001 (TS 3.3 – Class B Profile) standard noted a discrepancy in the Link Access Protocol – Balanced (LAPB) objects to be supported by a standards compliant product.

Discussion: The 2001 (Class B Profile) base standard introduced support for a number of objects within the `lapbOperTable` object as defined in RFC 1381. A draft amendment to the base standard, Amendment 1, changed the support of these objects to corresponding objects in the `lapbAdmnTable` with one exception, `lapbOperPortID`. RFC 1381 does not have a corresponding `lapbAdmnPortId` object, therefore, it is speculated that the inclusion of the `lapbOperPortID` is correct, or that RFC 1381 is incomplete. Speculating that RFC 1381 is correct leads to the following. The `lapbOperPortID` object is an entry in the `lapbOperTable` object. Since the `lapbOperPortID` object is contained within a table object, it can only be accessed through the table's index (`lapbOperIndex`) thus, the `lapbOperIndex` object must be supported. Additionally, in order to support the `lapbOperIndex` object, the `lapbOperEntry` and `lapbOperTable` objects must be supported as well.

Effect/Severity: (0) Major/Compatibility, (0) Minor/Completeness,
(-) Major/Usability

Conclusion: Use of "non-TCIP" standards in defining NTCIP standards benefits the ITS community in that the SDOs do not have to "re-invent-the-wheel", thus facilitating the development and ratification of standards. However, reliance on "non-TCIP" standards introduces additional risks to the suitability, effectiveness, and interoperability/interchangeability of NTCIP standards. As is the case shown here, potential problems with referenced standards can introduce problems and complexities if those standards are not complete, accurate, and provide the functionality needed in the NTCIP and ITS domains. In this instance, the `lapbOperPortID` object is not crucial to the operation of an NTCIP DMS subsystem and therefore, its negative impact can be viewed as minor.

Recommendation: Obtain clarification on support of an object named `lapbAdmnPortID` in RFC 1381 from the Internet Activities Board (IAB). If RFC 1381 is flawed, in that it supports an object named `lapbAdmnPortID, then` modify Amendment 1 to reflect support of the `lapbAdmnPortID` object. If RFC 1381 is correct, add support for the `lapOperTable`, `lapbOperEntry`, and `lapbOperIndex` objects in Amendment 1.

AS-5: Gauge Syntax

Analysis of draft Amendment 1 to the 1201 (TS 3.4) standard showed the use of a previously undefined object syntax, gauge.

Discussion: The Global Object Definitions Amendment 1 added support for a mandatory Security Conformance Group. Within this group, a mandatory object named `communityNameAccessMask` is defined as a 32-bit mask that can be used to associate "write access" to objects within a community name. The complete description of this object is shown below. The syntax chosen for this object is of type gauge that has no reference in the base standard or the amendment. In order to successfully compile a MIB, every object syntax must be defined in the MIB or included within an import statement. Neither of these conditions exists in either the base standard or the amendment.

```
2.8.3.3  User Community Name Mask Parameter
communityNameAccessMask OBJECT-TYPE
SYNTAX  GAUGE (0..4294967295)
ACCESS  read-write
STATUS  mandatory
DESCRIPTION
"This object defines a 32 bit mask that can be used to associate 'write access'
with a community name.  A value of 0x00000000 grants the community name user
read-only access and overrides any individual object's read-write access
clause.  A value of OxFFFFFFFF grants the community name user read-write access
and an individual object's read-write access clause applies.  Values other
0x00000000 and 0xFFFFFFFF are implementation specific and may limit viewing
and/or accessing the information in a device."
DEFVAL  { 4294967295 }
::= { communityNameTableEntry 3 }
```

Effect/Severity: (-) Major/Correctness, (-) Major/Testability

Conclusion: In order to access and test this object, its syntax must be understood. In the event that an undefined syntax occurs within a MIB, the reference implementation test methodologies cannot be employed. Likewise, if other software packages rely on similar methods for instantiating objects of a DMS for manipulation, they will likely fail or function incorrectly. Prior to the test, the 1201 MIB was altered to reflect the import of the gauge syntax from RFC 1155 so that testing could be undertaken with the reference implementation.

Recommendation: Modify 1201 (TS 3.4) Amendment 1 to include an import statement of the gauge syntax from RFC 1155.

AS-6: Community Name Index

Analysis of draft Amendment 1 to the 1201 (TS 3.4) standard showed the access setting of the `communityNameIndex` object as not-accessible.

Discussion: The Global Object Definitions Amendment 1 added support for a mandatory Security Conformance Group. Within this group, a mandatory object named

`communityNameIndex` is defined as the index to the rows contained within the `communityNameTable` object. The community name table provides flexibility and security in manipulating MIB objects within 1201 and other standards and is a potentially valuable feature. Unlike all other table index objects providing access to entries in a table, this object is marked as not-accessible, indicating that it can not be used to access and manipulate values within the table. The `communityNameIndex` parameter, shown in bold text, and its interrelated objects as defined in Global Object Definitions Amendment 1 are shown below.

```
--2.8.3 Community Names Table

communityNameTable OBJECT-TYPE
SYNTAX  SEQUENCE OF CommunityNameTableEntry
ACCESS  not-accessible
STATUS  mandatory
DESCRIPTION
"See standard."
::= { security 3 }

communityNameTableEntry   OBJECT-TYPE
SYNTAX  CommunityNameTableEntry
ACCESS  not-accessible
STATUS  mandatory
DESCRIPTION
"See standard."
INDEX { communityNameIndex }
::= { communityNameTable 1 }

CommunityNameTableEntry ::= SEQUENCE {
   communityNameIndex   INTEGER,
   communityNameUser    OCTET STRING,
   communityNameAccessMask    Gauge }

--2.8.3.1 Community Name Index Parameter

communityNameIndex   OBJECT-TYPE
SYNTAX  INTEGER (1..255)
ACCESS  read-only
STATUS  mandatory
DESCRIPTION
"See standard."
::= { communityNameTableEntry 1 }

--2.8.3.2 User Community Name Parameter

communityNameUser   OBJECT-TYPE
SYNTAX  OCTET STRING (SIZE(6..16))
ACCESS  read-write
STATUS  mandatory
DESCRIPTION
"See standard."
DEFVAL{"public"}
::= { communityNameTableEntry 2 }

--2.8.3.3 User Community Name Parameter

communityNameAccessMask   OBJECT-TYPE
SYNTAX  Gauge
ACCESS  read-write
STATUS  mandatory
DESCRIPTION
"See standard."
::= { communityNameTableEntry 3 }
```

Effect/Severity: (-) Major/Correctness, (-) Major/Testability, (-) Serious/Usability

Conclusion: In order to manipulate and record the object values contained within the `communityNameTable` table, access to the rows within the table must be supported. Since the `communityNameIndex` object is defined as the object entry point for the records within the table, it must be marked as something other than not-accessible. A more appropriate access type would be read-only.

Recommendation: Modify Amendment 1 to change the access type of the `communityNameIndex` object to read-only.

AS-7: Event Configuration Mode

Analysis of the 1201 (TS 3.4) base standard and draft Amendment 1 to the standard indicated the use of an undefined object.

Discussion: The Global Object Definition Amendment 1 defines an object named `eventConfigMode`. The valid syntax is an enumerated integer. The description of the second listing, `onChange`, indicates that a log entry is to be created when the value referenced by the `eventTypeOID` changes. The definitions of the `eventConfigMode`, in bold text, as well as a related object, as defined in the amendment to the standard, are shown below. It is speculated that the correct object to be referenced for this mode is the `eventConfigCompareOID`. Additionally, it is implied that only objects that are defined with integer syntax can be used for the `greaterThanValue`, `smallerThanValue`, and `hystersisBound` configuration modes.

```
--2.5.2.3 Event Log Configuration Mode Parameter

eventConfigMode OBJECT-TYPE
SYNTAX  INTEGER { other (1),
                  onChange (2),
                  greaterThanValue (3),
                  smallerThanValue (4),
                  hysteresisBound (5),
                  periodic (6) }
ACCESS  read-write
STATUS  mandatory
DESCRIPTION
"This object specifies the mode of operation for this event.  All checks and
entries to the table must occur within one second of the condition becoming
true. The modes are defined as follows:
VALUE   DESCRIPTION
onChange            create a log entry when value referenced by the
                    eventTypeOID changes
greaterThanValue    create a log entry when the object value becomes greater
                    than the value referenced to by the eventCompareValue
                    object, if this value is exceeded for the amount of time
                    specified in the eventConfigCompareValue2 object (in tenth
                    of seconds) and this value is greater than zero (0). A
                    value of zero (0) for eventConfigCompareValue2 indicates
                    immediate logging.
smallerThanValue    create a log entry when the object value becomes less than
                    the value referenced to by the eventCompareValue object, if
                    this value is exceeded for the amount of time specified in
                    the eventConfigCompareValue2 object (in tenth of seconds)
                    and this value is greater than zero (0). A value of zero
                    (0) for eventConfigCompareValue2 indicates immediate
                    logging.
hysteresisBound     creates a log entry when the object value becomes either
                    less than the lowerbound value or greater than the
```

```
                    upperbound value.  The lowerbound value is the lower value
                    of the eventConfigCompareValue- and the
                    eventConfigCompareValue2-objects, the upperbound is the
                    other value."
::= { eventLogConfigEntry 3 }

--2.5.2.6 Event Log Configuration Compare Object Identifier Parameter

eventConfigCompareOID OBJECT-TYPE
SYNTAX  OBJECT IDENTIFIER
ACCESS  read-write
STATUS  mandatory
DESCRIPTION
"This object contains the object identifier which points to the value that is
to be used to compare it to the detected value for this event."
::= { eventLogConfigEntry 6 }
```

Effect/Severity: (-) Major/Correctness, (-) Major/Usability

Conclusion: Correcting the standard to reflect the appropriate object name for the `onChange` configuration mode value is a minor modification. Support for syntax other than integer can increase the complexity of the standard. It could be argued that the integer syntax can accommodate the majority of objects to be used in a greater than, less than, and hysteresis bound comparison. One omission that may be of value is the counter syntax typically used to indicate time. Writing event logs based on time could provide benefit in verifying that messages are displayed at a certain time or traffic control patterns are modified according to rush hour traffic.

Recommendations:

1. Modify 1201 (TS 3.4) Amendment 1 to change the description of the referenced object for the `onChange` configuration mode to `eventConfigCompareOID`.
2. Investigate the use of other types of syntax for the `eventConfigCompareValue` objects.

AS-8: Low Fuel Threshold

Analysis of the 1203 (TS 3.6) base standard indicated a range that could be in error.

Discussion: The low fuel threshold object (`lowFuelThreshold`) syntax is an integer whose range is 0 to 255. This object indicates the level of fuel in the tank, as a percentage of the total capacity of the tank. This object's intention is to alert the user to a possible low fuel condition. As a percentage, the valid range of should be 0 to 100. The `lowFuelThreshold` object, as defined in the standard, is detailed below.

```
--2.11.3.1.1.2 Low Fuel Threshold Parameter
lowFuelThreshold OBJECT-TYPE
SYNTAX    INTEGER (0..255)
ACCESS    read-write
STATUS    optional
DESCRIPTION "Indicates the low fuel level threshold used to alert the user.  The
threshold is indicated as a percent (%) of a full tank.  When the level of fuel
is below the threshold, the bit for power alarm (bit 2) in the shortErrorStatus-
object shall be set to one (1)."
::= {statPower 2}
```

Effect/Severity: (0) Minor/Correctness, (0) Major/Usability

Conclusion: While the standard covers the acceptable range of values to produce the desired result of this object's function, an incorrectly set value may never trigger the desired effect. Thus, a change to the standard should be considered.

Recommendation: Modify the standard with an amendment that lists the valid range of the `lowFuelThreshold` object from 0 to 100.

AS-9: 1203(TS 3.6 Standard Typographical Issues and Edits

A collection of minor editing inconsistencies and errors found in 1203 (TS 3.6).

Discussion: In the course of analyzing the 1203 (TS 3.6) standard, a number of minor typographical or editing errors were noticed. These items are listed below:

7. Section 3.4 contains a table listing the flags that can be used with the MULTI syntax language. The Spacing Character tag should include a closing flag of "/sc" in the appropriate column.

8. Section 3.4.5 references objects named `fontDefinitionUserID`, `fontDefinitionIndex`, and `fontDefintion`. These objects should be named `fontNumber`, `fontIndex`, and `fontTable` respectively.

9. The MIB defined in the standard lists the names of two objects, `maxAuxIODigital` and `maxAuxIOAnalog` to describe the number of auxiliary digital and analog ports contained in the auxiliary port table, respectively. Section 4.13 of the standard, which details the objects contained in the Auxilliary I/O Conformance Group, lists these object names as `maxAuxAnalog` and `maxAuxDigital`. Additionally, the objects contained in the `auxTable` are labeled incorrectly in Section 4.13. The MIB shows the names of these objects to contain the string "IO" after "aux". This string is omitted in section 4.13 for the table objects.

10. The MIB defined in the standard lists the names of two objects as `dmsIllumBrightnessValuesError` and `dmsIllumBrightLevelStatus`. Section 4.11 of the standard, which details the objects contained in the Illumination/Brightness Conformance Group, lists these object names as `dmsIllumBrightnessValuesStatus` and `dmsIllumBrightStatus` respectively.

11. The MIB defined in the standard lists an object named `dmsMessageStatus`. Section 4.6 of the standard, which details the objects contained in the Message Table Conformance Group lists the name of this object as `dmsMessageMsgStatus`.

12. The `fontIndex` object has been defined with access of read-write-only. It is speculated that the access for this object should be marked as read-only.

13. The `defaultJustificationLine`, `defaultPageOn`, `defaultPageOff`, and `defaultCharactersSet` objects have been defined with an access of read-write-write. It is speculated that the access for these objects should be marked as read-write.

Effect/Severity: (0) Minor/Consistency, (0) Minor/Correctness

Conclusion: These items are somewhat cosmetic in nature and do not greatly influence the suitability, effectiveness, and interoperability/interchangeability of the standard.

Recommendation: Modify the standard with an amendment that corrects these anomalies.

AS-10: 1203 (TS 3.6) Standard Clarifications

During the analysis of the 1203 (TS 3.6) standard a number of issues were identified where additional information could prove to be beneficial.

Discussion: In the course of analyzing the standard, a number of ambiguities or lack of information were uncovered and are detailed below:

14. The definition of the `MessageActivationCode` syntax does not define the unit of measurement for the duration of the message. It is speculated that the unit of measurement is minutes from information describing the functionality of the `dmsMessageTimeRemaining` object.

15. The standard does not define whether setting the bit to 0 or 1 indicates support of the identified value for the `dmsSignAccess` and `dmsSignTechnology` objects. It is speculated that setting a bit to 1 indicates support of the value assigned to that bit.

16. The temperature type fields in the MULTI language specification do not indicate whether this temperature is the ambient temperature or some other temperature value. It is speculated that the temperature value is the ambient temperature determined by the temperature device.

17. It is not clear what invalidating a row when setting `fontHeight` to 0 means. This could be interpreted as deleting the characters in the `characterTable` and all the font information in the `fontTable` for the particular font in order to free memory usage or simply to make these values unavailable.

18. The `dmsMessageTimeRemaining` is set to read-write. This implies that you could set this object to extend the duration of the currently displayed message. Is this functionality intended for this object?

19. The purpose of the `statMultiField` objects are unclear. The purpose of these objects could be inferred to indicate the current value of a MULTI language syntax field as displayed on a sign; or the value of each of these fields regardless of their use in a currently displayed message. If these objects intended usage are characterized by the first assumption, could obtaining the MULTI string of the message in the current buffer provide the same information.

20. The purpose of the `watchdogFailureCount`, which describes the number of watchdog failures that have occurred, was unclear. Addition of information in the description of the object's purpose may be considered. Additionally, information concerning the epoch from which these counts have accumulated from may also provide beneficial. Perhaps an object providing the time since the `watchogFailureCount` was instantiated and an object to reset or clear the object may be of use.

Effect/Severity: (0) Minor/Efficiency, (0) Minor/Simplicity, (0) Minor/Unambiguous

Conclusion: These issues may not influence the suitability, effectiveness, and interoperability/interchangeability of the currently approved standard. However, consideration of these clarifications is recommended.

Recommendations:

1. Investigate the insertion of information to clarify the issues identified herein for incorporation into a future amendment to the 1203 (TS 3.6) base standard.
2. Provide a complimentary document for the standard such as a implementation or guideline document that provides additional information for the issues identified herein.

AS-11: 1203 (TS 3.6) Standard Modifications

During the analysis of the 1203 standard, a number of issues were identified where modification to the standard could prove to be beneficial.

Discussion: In the course of analyzing the standard, a number of areas where additional objects and information may increase the usability and productivity of the standard were identified. These articles are listed below.

21. Consider using a 16-bit bitmap integer for the `dmsValidateMessageError` and `dmsActivateMessageError` objects instead of an enumerated integer. Use of the enumerated integer, as defined in the standard, only reports the last error observed if multiple errors are generated. Using a bitmap supports the identification of multiple error types by setting a bit to 1 if the error is observed. This approach can identify errors of multiple types.

22. Consider renaming the `maxAuxIODigital` and `maxAuxIOAnalog` objects. These objects describe the number of rows in the `auxIOTable` for the particular port type and not the maximum number supported by the table. Additionally, the addition of the values for the objects should not be greater than 255.

23. Consider adding objects for the beacon service that function similarly to the objects defined for pixel service related to the status error objects group

24. The pixel failure table should be cleared when the `pixelTestActivation` object is set to "test" (3) or "clearTable" (4).

25. Consider the addition of objects to support multiple fans, power supplies, and lamps, as well as objects describing the number of items, tables describing types, and test objects to initiate and report test conditions and results.

Effect/Severity: (0) Minor/Productivity, (0) Minor/Usability

Conclusion: These articles do not greatly influence the suitability, effectiveness, and interoperability/interchangeability of the currently approved standard. However, consideration of these additions is recommended. Note that some of the modifications detailed above, such as changing an object name, may adversely impact deployed products adhering to the current standard.

Recommendation: Investigate amending the standard with the articles detailed above after analyzing the effects of such additions and receiving input from various groups with a specific interest in the standard.

AS-12: Core Functions

Prior to the testing of the NTCIP standards related to Dynamic Message Signs, a collection of core functions were identified that characterize the behavior of a DMS. Testing of these functions was emphasized.

Discussion: In developing the procedures for testing DMS, various entities, such as the NTCIP Joint Committee, expressed concern over the lack of support for testing functions. A preliminary list of core functions was developed by the NTCIP Joint Committee and ISTT members and disseminated to interested parties, including DMS manufacturers. Each interested party had the opportunity to provide comments related to the accuracy and completeness of this list. The finalized list of core functions that would be addressed during the standards testing process is shown below:

Control Sign Display Functions

Display a message on a sign
Blank a sign

Create a Message Functions

Build a new message
Delete a message
New line
New page
Flash message
Justify line
Justify page
Select Font

Exceptional Sign Control Functions

Default display condition following end of message

Scheduled Control Functions

Configure time-base schedule
Configure day plan
Configure action table
Run the schedule

Monitor Sign Display Status Functions

Adjust display brightness
View active message
Detect pixel errors
Identify source of message

Effect/Severity: (0) Minor/Simplicity

Conclusion: The existence of core functions are not identified in the standard. While not a prerequisite for contributing positively to the suitability, effectiveness, and interoperability/interchangeability of the standard, these functions do characterize the basic essential services of a DMS. Thus, their implementation is a critical factor. The standard provides the means for realizing these core functions but the information related to the manipulation and interaction of objects is difficult to glean and understand.

Recommendation: Generate a companion document to the standard, such as an implementation guide, that details the manipulation of objects, as envisioned by the SDO, to realize the core functions deemed essential for a DMS.

Summary of Findings

Findings by "-ilities" Rating of Effect/Severity

The 24 findings discussed above are summarized in Table 3 below. This table contains the test team's consensus opinion regarding the effect and severity of the finding on the community of standards in this NTCIP DMS domain. These ratings are associated with the "-ility" that applies according to the definitions provided in Tab A. At the left of Table 3 are the standards determined to be affected by each of the findings.

Table 3: Mapping of Findings to "-ilities" with Effect / Severity

1101 (TS 3.2)	2001 (TS 3.3)	2301 (TS 3.STMF)	2101 (TS 3.PMP2320)	1201 (TS 3.4)	1203 (TS 3.6)	**Categories of Findings:** • Interview Comment – IC • Test Results – TR • Analysis of Standards - AS	Compatibility	Completeness	Consistency	Correctness	Efficiency	Productivity	Simplicity	Testability	Unambiguous	Usability
Interview Comment (IC) Findings																
						IC-1 Global Local Time (also TR-2)		(0) Minor								
						IC-2 Scheduler (also TR-1)		(-) Major			(-) Major					
						IC-3 Power Supply (also TR-4)		(-) Major							(-) Minor	(-) Major
						IC-4 Multiple Light Sensors (also TR-3)		(-) Major							(-) Minor	(-) Major
						IC-5 No Capability to do Graphics		(-) Minor								

Categories of Findings:

- **Interview Comment – IC**
- **Test Results – TR**
- **Analysis of Standards - AS**

1101 (TS 3.2)	2001 (TS 3.3)	2301 (TS 3.STMF)	2101 (TS 3.PMP232)	1201 (TS 3.4)	1203 (TS 3.6)		Compatibility	Completeness	Consistency	Correctness	Efficiency	Productivity	Simplicity	Testability	Unambiguous	Usability
						IC-6 Lack of Communications to obtain guidance on NTCIP Standards							(0) Major			
Test Results (TR) Findings																
						TR-1 Scheduler Object (also IC-2)		(-) Major			(-) Major			(-) Major			
						TR-2 Global Local Time Differential (also IC-1)		(0) Minor									(0) Minor
						TR-3 Support For Multiple Light Sensors (also IC-4)		(-) Major								(-) Minor	(-) Major
						TR-4 Support for Multiple Power Supplies (also IC-3)		(-) Major								(-) Minor	(-) Major
						TR-5 Illumination Brightness			(-) Major				(-) Minor			(-) Major	
						TR-6 Message MultiString CRC	(-) Minor		(-) Minor			(-) Minor		(-) Minor	(-) Minor	(-) Minor	
Analysis of Standards (AS) Findings																
						AS-1 Maximum Temperature of Sign Housing Parameter			(-) Minor								*(0) Major*
						AS-2 External Reference Consistency Issues	(-) Major		(-) Major								
						AS-3 Network Layer			*(0) Minor*								
						AS-4 LAPB MIB Objects	*(0) Major*	*(0) Minor*									*(-) Major*

Categories of Findings:

- **Interview Comment – IC**
- **Test Results – TR**
- **Analysis of Standards - AS**

1101 (TS 3.2)	2001 (TS 3.3)	2301 (TS 3.STMF)	2101 (TS 3.PMP232)	1201 (TS 3.4)	1203 (TS 3.6)		Compatibility	Completeness	Consistency	Correctness	Efficiency	Productivity	Simplicity	Testability	Unambiguous	Usability
						AS-5 Gauge Syntax				*(-) Major*				*(-) Major*		
						AS-6 Community Name Index				*(-) Major*				*(-) Major*		*(-) Serious*
						AS-7 Event Configuration Mode				*(-) Major*						*(-) Major*
						AS-8 Low Fuel Threshold				*(0) Minor*						*(0) Major*
						AS-9 1203 (TS 3.6) Standard Typographical Issues and Edits			*(0) Minor*	*(0) Minor*						
						AS-10 1203 (TS 3.6) Standard Clarifications					*(0) Minor*		*(0) Minor*		*(0) Minor*	
						AS-11 1203 (TS 3.6) Standard Modifications						*(0) Minor*				*(0) Minor*
						AS-12 Core Functions							*(0) Minor*			

Findings by Assessment and Evaluation Category Rating of Effect/Severity

Table **4** illustrates the mapping of findings to the assessment and evaluation categories of Suitability, Effectiveness and (contribution to) Interoperability/interchangeability. This mapping is accomplished by considering the ratings assigned in Table 3 together with the cross-reference provided in Table 1 showing how the "-ilities" impact the categories. The least favorable/worst case for each collection is used. For example, if a finding were rated as (0) Minor for Compatibility, and (-) Major for Completeness, this table entry would use (-) Major as the rating for Effectiveness and Interoperability/interchangeability since both "-ilities" affect both categories, and (-) Major is the least favorable/worst case rating.

Table 4: Categorical Impacts of Findings

1101 (TS 3.2)	2001 (TS 3.3)	2301 (TS 3.STMF)	2101 (TS 3.PMP2320)	1201 (TS 3.4)	1203 (TS 3.6)	**Findings listed below are related to Assessment and Evaluation Categories >>**	**Suitability**	**Effectiveness**	**Interoperability/ Interchangeability**
Interview Comment (IC) Findings									
						IC-1 Global Local Time (also TR-2)	(0) Minor	(0) Minor	(0) Minor
						IC-2 Scheduler (also TR-1)	(-) Major	(-) Major	(-) Major
						IC-3 Power Supply (also TR-4)	(-) Major	(-) Major	(-) Major
						IC-4 Multiple Light Sensors (also TR-3)	(-) Major	(-) Major	(-) Major
						IC-5 No Capability to do Graphics	(-) Minor	(-) Minor	(-) Minor
						IC-6 Lack of Communications to obtain guidance on NTCIP Standards	(0) Major	(0) Major	
Test Results (TR) Findings									

1101 (TS 3.2)	2001 (TS 3.3)	2301 (TS 3.STMF)	2101 (TS 3.PMP232)	1201 (TS 3.4)	1203 (TS 3.6)	**Findings listed below are related to Assessment and Evaluation Categories >>**	Suitability	Effectiveness	Interoperability/ Interchangeability
						TR-1 Scheduler Object (also IC-2)	(-) Major	(-) Major	(-) Major
						TR-2 Global Local Time Differential (also IC-1)	(0) Minor	(0) Minor	(0) Minor
						TR-3 Support For Multiple Light Sensors (also IC-4)	(-) Major	(-) Major	(-) Major
						TR-4 Support for Multiple Power Supplies (also IC-3)	(-) Major	(-) Major	(-) Major
						TR-5 Illumination Brightness	(-) Major	(-) Major	(-) Major
						TR-6 Message MultiString CRC	(-) Minor	(-) Minor	(-) Minor
Analysis of Standards (AS) Findings									
						AS-1 Maximum Temperature of Sign Housing Parameter	(-) Minor	(-) Minor	(-) Minor
						AS-2 External Reference Consistency Issues	(-) Major	(-) Major	(-) Major
						AS-3 Network Layer	(0) Minor	(0) Minor	(0) Minor
						AS-4 LAPB MIB Objects	(-) Major	(-) Major	(0) Major
						AS-5 Gauge Syntax		(-) Major	(-) Major
						AS-6 Community Name Index	(-) Serious	(-) Serious	(-) Major
						AS-7 Event Configuration Mode	(-) Major	(-) Major	(-) Major
						AS-8 Low Fuel Threshold	(0) Major	(0) Major	(0) Minor
						AS-9 1203 (TS 3.6) Standard Typographical Issues and Edits	(0) Minor	(0) Minor	(0) Minor

1101 (TS 3.2)	2001 (TS 3.3)	2301 (TS 3.STMF)	2101 (TS 3.PMP232)	1201 (TS 3.4)	1203 (TS 3.6)	Findings listed below are related to Assessment and Evaluation Categories >>	Suitability	Effectiveness	Interoperability/ Interchangeability
						AS-10 1203 (TS 3.6) Standard Clarifications	(0) Minor	(0) Minor	(0) Minor
						AS-11 1203 (TS 3.6) Standard Modifications	(0) Minor	(0) Minor	
						AS-12 Core Functions	(0) Minor	(0) Minor	

Findings by Overall Effect/Severity

The following table (Table 5) summarizes the findings by Effect/Severity. The findings have multiple ratings on several dimensions (as shown in Table 3) but are not duplicated here. The purpose of this summary is to illustrate the "worst case" associated with each finding, thus the top left corner of the table is "Worst", the bottom right is "Best".

Table 5: Summary of Effect/Severity Ratings by Finding

	Negative (-)	Neutral (0)
Critical	*A mission critical showstopper. A standard flawed to this degree shall be corrected; immediate solution and amendment delivered by industry bulletin is strongly suggested.*	*Potential for a critical showstopper but dependent on other implementation unique factors. A standard flawed to this degree shall be corrected; immediate amendment by industry bulletin is strongly suggested.*
	None	**None**
Serious	*A significant impediment with no workaround. A standard deficient to this degree shall be corrected; immediate amendment by industry bulletin is suggested.*	*Potential for a significant impediment with no workaround but dependent on other implementation unique factors. A standard deficient to this degree shall be corrected; immediate amendment by industry bulletin is suggested.*
	(1) AS-6	**None**
Major	*A significant problem but with a workaround. A standard deficient to this degree should be corrected; near term amendment is suggested.*	*Potential for a significant problem but with a workaround and dependent on other implementation unique factors. A standard deficient to this degree should be corrected; near term amendment is suggested.*
	(10) IC-2, IC-3, IC-4, TR-1, TR-3, TR-4, TR-5, AS-2, AS-4, AS-5 and AS-7	**(4) IC-6 and AS-8**
Minor	*An inconvenience or annoyance. The standard should be corrected; action in the normal course of periodic review and update is suggested.*	*Potential inconvenience or annoyance. The standard should be corrected; action in the normal course of periodic review and update is suggested.*
	(2) IC-5, TR-6 and AS-1	**(7) IC-1, TR-2, AS-3, AS-9, AS-10, AS-11 and AS-12**
	(15) Negatives (-)	**(9) Neutrals (0)**

Note that while there are 24 findings discussed and mapped, there are four findings in IC and TR that are related by topic. These are enumerated below:

- IC-1 & TR-2 Global Time issues
- IC-2 & TR-1 Scheduler issues
- IC-3 & TR-4 Power Supply issues
- IC-4 & TR-3 Light Sensor issues

Tab A - The "-ilities" Defined

Element	Definition(s) (several sources)	Ant/(Syn)	Criteria	Rationale/Example(s)
Compatibility	Capability of existing or operating together in harmony *The capability of two or more items or components of equipment or material to exist or function in the same system or environment without mutual interference.* ***The ability of two or more systems or components to perform their required functions while sharing the same hardware or software environment.***	Incompatible	A standard shall be compatible with all other related standards including those that are predecessors, peers and successors in terms of how they are utilized in an implementation.	If a standard is incompatible with those around it, this will likely cause the user/vendor to develop suitable workaround(s) to "solve the problem". This then leads to the potential for inefficiency of the implementation. And, unless all the vendor workarounds are identical/similar, this also has a divergent negative impact on system interoperability/interchangeability. **Effectiveness, Interoperability/interchangeability**
Completeness	Having all necessary parts, elements or steps.	Incomplete	A standard shall be complete in that it will contain all the necessary parts, elements or steps to accomplish the intended purpose.	If a standard lacks one or more of the parts needed for its use to achieve the intended purpose, then the user/vendor must unilaterally develop this "gap-filler". Since the standard lacks needed features, it is less suitable for the intended application. The fix will most often be a unique-interpretation or a "custom workaround" which further affects effectiveness and interoperability/interchangeability. **Suitability, Effectiveness, Interoperability/interchangeability**
Consistency	Agreement or harmony of parts or features to one another or a whole. ***The degree of uniformity, standardization, and freedom from contradiction among the documents or parts of a system or component.***	Inconsistency; inconsistent	A standard shall be consistent in that there will be agreement, uniformity, standardization and no contradiction in usage of terms, definitions, attributes or features.	If the standard is inconsistent and disagrees within itself and its domain, this will likely cause the user/vendor to develop suitable workaround(s) to "solve the problem". This then leads to the potential for inefficiency of the implementation. And, unless all the vendor solution "gap-filler" workarounds are identical/similar, this also has a divergent negative impact on system interoperability/interchangeability. **Effectiveness, Interoperability/interchangeability**

Element	Definition(s) (several sources)	Ant/(Syn)	Criteria	Rationale/Example(s)
Correctness	*Extent to which a program satisfies its specification and fulfills the user's mission objectives.* ***The degree to which a system or component is free from faults in its specification, design, and implementation***	Incorrectness; incorrect	A standard shall be correct in that it will be free from faults in its specification, design and implementation.	If the standard is incorrect in one or more of its "specifications", this will likely cause the user/vendor to develop suitable interpretations or workaround(s) to "solve the problem". This then leads to the potential for inefficiency of the implementation. And, unless all the vendor solution workarounds are identical/similar, this also has a divergent negative impact on system interoperability/interchangeability. **Effectiveness, Interoperability/interchangeability**
Efficiency	The quality or degree of being efficient; productive of desired effects, productive without waste. *The amount of computing resources and code required by a program to perform a function.* ***The degree to which a system or component performs its designated functions with minimum consumption of resources.***	Inefficiency; inefficient	A standard shall be efficient in that it is productive of the desired effects and can be used to accomplish these desired effects with minimum consumption of resources.	If a standard is cumbersome or inefficient to use, this by consequence will make it less suitable for use and could potentially lead to inefficient or ineffective implementations. **Suitability, Effectiveness**
Productivity	The quality or state of being productive; effective in bringing about; yielding or furnishing results, benefits or profits.	(~Effective)	A standard shall enhance productivity in that it contributes positively to yielding results or benefits.	Similar to efficiency, if a standard does not enhance productivity, this will make it less of a positive influence in effective design and implementation. **Effectiveness**
Simplicity	The state of being simple or uncompounded; readily understood or performed.	Complexity; complex	A standard shall be simple in that it will be uncompounded, readily understood and easy to apply.	If a standard is complex and difficult to understand, this makes it less suitable for use and could potentially lead to inefficient or ineffective implementations. **Suitability, Effectiveness**
Testability	To undergo a test; to apply a test as a means of analysis or diagnosis. *Effort required to test a program to ensure it performs its intended function.*	Untestable	A standard shall be testable in that the standards features embodied in an implementation are clearly traceable to the elements of the standard from which they are derived.	If the features of one or more related standard lack traceability to/from each other, this greatly complicates the testability of those features with potential negative impact on the ability to properly confirm system interoperability/interchangeability. **Interoperability/interchangeability**

Element	Definition(s) (several sources)	Ant/(Syn)	Criteria	Rationale/Example(s)
Unambiguous	Not ambiguous; clear, precise; (ambiguous) doubtful or uncertain; capable of being understood in two or more possible senses or ways.	Ambiguous; (clarity)	A standard shall be unambiguous in that it will be clear, precise and shall be understood in one and only one way.	If the standard is ambiguous in one or more of its "specifications", this will likely cause the user/vendor to develop suitable interpretations or workaround(s) to "solve the problem" potentially with an incorrect or custom implementation. This then leads to the potential for inefficiency of the implementation. And, unless all the vendor solution workarounds are identical/similar, this also has a divergent negative impact on system interoperability/interchangeability. **Effectiveness, Interoperability/interchangeability**
Usability	Capable of being used; convenient and practicable for use. *Effort required to learn, operate, prepare input and interpret output of a program.* ***The ease with which a user can learn to operate, prepare inputs for, and interpret outputs of a system or component.***	Unusable; impractical	A standard shall be usable in that it will be convenient and practical for the intended use.	If a standard is impractical or not usable for whatever reasons, this clearly makes it less suitable for use and could potentially lead to inefficient or ineffective implementations. **Suitability, Effectiveness**

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Tab B - DMS Vendor, User/Operator, Maintenance Interview Questionnaire

Questionnaire

ITS Standards Test Program
Dynamic Message Signs (NEMA TS 3.6-1996)

Introduction

The U.S. Department of Transportation Federal Highway Administration (DOT/FHWA) is considering rulemaking for standards. In this case, rulemaking would mean that any Dynamic Message Signs procured with Federal money would have to comply with NEMA standard TS 3.6-1996 NTCIP Object Definitions for Dynamic Message Signs (DMS). This would also include the use of NEMA TS 3.4, NTCIP Global Object Definitions. As NEMA TS 3.6 references and incorporates NEMA TS 3.4.

Similar rules would also mandate the use of the NTCIP communications protocol Standards such as SNMP, STMF, etc.

Prior to rulemaking it is vital to assess the standards to make certain they are clear, unambiguous and complete. In general terms we want to make certain the standard is suitable for its intended purpose, is effective, and is interoperable with other systems and equipment built to the same standard from both the equipment manufacturer's and operator's viewpoints.

General

Vendor

Completeness:

A. Is the standard complete?
   - A.1 Are there objects that should be added?
   - A.2 Are there any proprietary objects that you think should be considered as "industry standard" objects? Either as Global or DMS objects?
   - A.3 Are there MULTI (Mark Up Language for Transportation Information) tags that should be added?

B. Is the standard overstated?
   - B.1 Are there any "Mandatory" objects that are not needed?
   - B.2 Are there "Mandatory" objects that could be "Optional"?

B.3 Are there objects that are cost drivers without adding appropriate value?

Unambiguous:

Is the standard unambiguous?

Were there any areas where the designers sought interpretations as to what the standard "really meant"?

Any areas of the standard where NEMA was asked to clarify or interpret the standard?

Any part of the standard where NEMA was advised as to an error in the standard?

Clarity:

Is the standard clear?

Were there any areas of the standard that were not understandable?

Were there any areas of the standard where the designers needed or sought guidance or clarification?

Operator (NA to vendor)

Completeness

Does the DMS (Built in accordance with the Standard) allow one to use the equipment as desired?

Are there tasks you would like to accomplish, but can not?

Are there tasks/functions available you do not use?

Are there tasks/functions available you do not understand?

Are there tasks/functions available that you can not conceive of using?

Are there additional tasks/functions that you need or would like to have available?

Clear and Unambiguous

Are there DMS tasks or functions that are confusing or inappropriate?

Effectiveness

Is the DMS effective in informing the traveler of roadway/toll conditions or changes?

What additional functionality could improve the effectiveness of the signs?

Suitability

Is the Dynamic Message Sign suitable for the task?

Is there some additional functionality that would improve the DMS for the task?

Is there some other device that could be better for the task?

Specific Questions

Vendor

Is the set of normative references complete?

Are additional references required?

Is the set of informative references complete?

Are there additional informative references needed?

How would these additional informative references help in understanding the mandatory requirements of the standard and in developing the hardware/software?

Vendor and User

Is the set of objects sufficient?

Are additional objects needed?

Are there objects that you believe are not needed? Consider for “Message Objects”, “Scheduling Objects”, “Illumination Objects”, “Auxiliary I/O Objects” “Action Items Objects” and “Status Objects”.

Is the set of objects suitable for operating the sign and conveying information to the vehicle operators? Would additional objects help?

Does the set of objects allow effective control of the sign? Would additional objects help?

Does this set allow effective communication with the sign? Would additional objects help?

Does the set of objects allow interoperation between controllers and signs developed by different manufacturers? With other Traffic Management Centers?

The “Illumination” and “Brightness” level objects have large ranges: Illumination [Photocell] or background ranges from 0 to 65,535; Brightness [Sign] ranges from 0 to 255; and Illumination/Brightness ranges from 0 to 65,535.How did you interpret this? Is the standard really understandable? Could you recommend any alternative wording?

User/Operator

Is the set of sign objects (Access | Type | Height | Width | Border) sufficient to completely describe the sign? Are additional objects required?

Is the set of configuration objects (Character height and width | Sign height and width | Fonts | Characters per Font | Character Definition) suitable for conveying the necessary information to the vehicle operators?

Are there too many options in this set of configuration objects? Too few?

Are there any interoperability/interchangeability concerns that derive from this diversity of fonts and characters?

Maintenance

There are a number of objects that provide status information on the sign and its components. (Open Door Status | Pixel Failure | Fan Test | Fan Status | Sign Voltage | Low Fuel | Temperature…). Does this provide sufficient information to allow correcting malfunctions of the dynamic message sign on a single visit?

Are additional status objects needed to allow sufficient "troubleshooting" from a remote location for single visit correction of a sign malfunction?

Other (Not Applicable)

There are 27 conformance groups applicable to Dynamic Message Signs (See NEMA TS 3.6, Table 5-1), only four (4) conformance groups are mandatory the other 23 conformance groups are optional.

Did you select to procure a sign using one or more optional conformance groups?

Did you develop criteria for selecting these conformance groups?

If so, please explain the criteria.

Tab C - Test Coverage of Test Steps, Trials and Sessions

1101 (TS 3.2) NTCIP – Simple Transportation Management Framework (STMF)

Feature	Comments
Trial 1 – Dynamic Object Number	All Features Not Tested. Remarks: These features were not tested due to the following reasons: • Not required for implementation of DMS • Vendors do not support the features • Tested and substantiated through the use of NTCIP Exerciser
Trial 2 – Dynamic Object Index	
Trial 3 – Dynamic Object Variable	
Trial 4 – Dynamic Object Configuration Owner	
Trial 5 – Dynamic Object Configuration Status	

2001 (TS 3.3) NTCIP – Class B Profile

Session 1: RFC 1213 - System, Address Translation, and SNMP groups

Feature	Comments
Trial 1 – System Description	Tested a sample of trials. Out of a total of 34 trials, tested 7. No issues to report. Remarks: The ISTT tested only a sample of this session due to the following: • Not required for implementation of DMS • Not supported by vendors • Tested and substantiated through the use of NTCIP Exerciser
Trial 2 – System Object Descriptor	
Trial 3 – System Management UpTime	
Trial 4 – System Contact	
Trial 5 – System Descriptive Name	
Trial 6 – System Location	

Trial 7 – System Services Value	
Trial 8 – Address Translation Table	
Trial 9 – Delivered SNMP Messages	
Trial 10 – Generated SNMP Messages	
Trial 11 – Delivered Invalid SNMP Version	
Trial 12 – Delivered SNMP Unknown Community Name	
Trial 13 – Delivered SNMP Unauthorized Community	
Trial 14 – Encountered SNMP ASN.1 or BER Errors	
Trial 15 – Delivered SNMP Too Big Error Status PDUs	
Trial 16 – Delivered SNMP No Such Name Error Status PDUs	
Trial 17 – Delivered SNMP Bad Value Error Status PDUs	
Trial 18 – Delivered SNMP Read Only Error Status PDUs	
Trial 19 – Delivered SNMP General Error Status PDUs	
Trial 20 – Processed SNMP Get Request PDUs	
Trial 21 – Processed SNMP Get Next PDUs	
Trial 22 – Processed SNMP Set Request PDUs	
Trial 23 – Processed SNMP Get Response PDUs	
Trial 24 – Processed SNMP Trap PDUs	
Trial 25 – Generated SNMP Too Big Error Status PDUs	
Trial 26 – Generated SNMP No Such Name Error Status PDUs	
Trial 27 – Generated SNMP Bad Value Error Status PDUs	
Trial 28 – Generated SNMP General Error Status PDUs	
Trial 29 – Generated SNMP Get Request PDUs	
Trial 30 – Generated SNMP Get Next PDUs	
Trial 31 – Generated SNMP Set Request PDUs	
Trial 32 – Generated SNMP Get Response PDUs	
Trial 33 – Generated SNMP Trap PDUs	
Trial 34 – Management Agent Authentication Trap Enabled	

Session 2: RFC 1317 - RS-232 and Asynchronous Port tables

Feature	Comments
Trial 1 – Number of RS232 Ports	Tested a sample. Out of a total of 3 trials, tested 2 trials. No issues to report.

Trial 2 – RS232 Port Table (Mandatory for equipment with RS232-like interfaces, - mandatory table objects include rs232PortIndex, rs232PortType, rs232PortInSpeed, and rs232PortOutSpeed)	
Trial 3 – RS232 Asynchronous Port Table	

Session 3: RFC 1381 - LAPB Admn and operating tables

Feature	Comments
Trial 1 – Link Access Protocol-Balanced (LAPB) Read-Write Table (Mandatory for equipment that supports LAPB, - mandatory table objects include lapbAdmnIndex, lapbAdmnTransmitN1FrameSize, lapbAdmnReceiveN1FrameSize, lapbAdmnT1AckTimer, lapbAdmnT2AckDelayTimer, lapbAdmnT3DisconnectTimer, and lapbAdmnT4IdleTimer)	Not Tested. Remarks: These features were not tested due to the following reasons: • Not required for implementation of DMS • Related to ISO and other standards which are already mature and need not be tested • See comment under finding AS-4
Trial 2 – Link Access Protocol-Balanced (LAPB) Read Table (Mandatory for equipment that supports LAPB, - mandatory table object includes lapbOperPortId)	

Session 4: TS 3.4 - Security Conformance Group

Feature	Comments
Trial 1 – Community Name Administrator	Not Tested. Remarks: These features were not tested due to the following reasons: • Not required for implementation of DMS • Related to ISO and other standards which are already mature and need not be tested
Trial 2 – Maximum Community Names	
Trial 3 – Community Names Table	

The Data Transport Aspect features include those protocols used in realizing the following layers of the International Standards Organization (ISO) Open System Interconnection (OSI) Reference Model (RM):

Session 5: Layer 1 - Physical

Feature	Comments
Trial 1 – EIA/TIA-232-E Interface	Not Tested. Remarks: These features were not tested due to the following reasons: • Not required for implementation of DMS • Related to ISO and other standards which are already mature and need not be tested
Trial 2 – FSK Modem Interface	

Session 6: Layer 2 - Data Link

Feature	Comments
Trial 1 – Service Definition	Not Tested. Remarks: These features were not tested due to the following reasons: • Not required for implementation of DMS • Related to ISO and other standards which are already mature and need not be tested
Trial 2 – Protocol	
Trial 3 – Frame Structure	
Trial 4 – Frame Types	
Trial 5 – Procedures	
Trial 6 – Protocol Parameters	
Trial 7 – Protocol Service Mapping	

Session 7: Layer 3 - Network

Feature	Comments
Trial 1 – Protocol Identification	Not Tested. Remarks: These features were not tested due to the following reasons: • Not required for implementation of DMS • Related to ISO and other standards which are already mature and need not be tested • See comment under finding AS-3

Trial 2 – Service Definition	
Trial 3 – Usage of Data Link Layer Service	
Trial 4 – Packet Structure	
Trial 5 – Procedures	
Trial 6 – Protocol	
Trial 7 – Protocol to Service Mapping	

Session 8: Layer 7 - Application

Feature	Comments
Trial 1 – Service Definition	Not Tested. Remarks: These features were not tested due to the following reasons: • Not required for implementation of DMS • Related to ISO and other standards which are already mature and need not be tested
Trial 2 – Protocol	
Trial 3 – Protocol to Service Mapping	

1201 (TS 3.4) NTCIP – Global Object Definitions

Session 1: Configuration Conformance Group Session

Feature	Comments
Trial 1 – Global Set ID	Tested all trials. No issues to report.
Trial 2 – Maximum Modules	
Trial 3 – Module Table - Module Number	
Trial 4 – Module Table - Module Device Node	
Trial 5 – Module Table - Module Make	
Trial 6 – Module Table - Module Model	
Trial 7 – Module Table - Model Version	
Trial 8 – Module Table - Module Type	

Session 2: Security Conformance Group Session

Feature	Comments
Trial 1 – Community Name Administrator	Not field tested. Remarks: See comments under finding AS-6
Trial 2 – Maximum Community Names	
Trial 3 – Community Names Table – User Community Name	
Trial 4 – Community Names Table - User Community Name Mask	

Session 3: Database Management Conformance Group Session

Feature	Comments
Trial 1 – Database Creation Transaction	Not tested. Remarks: These features were not tested due to the following reasons: • Did not identify any issues through the pre-standard analysis process (interviews, etc) • Optional Conformance Group

Trial 2 – Database Verify Status	
Trial 3 – Database Verify Error	

Session 4: Time Management Configuration Conformance Group Session

Feature	Comments
Trial 1 – Global Time	Tested all trials as part of exception testing. Remarks: See comments under findings IC-1 and TR-2.
Trial 2 – Global Daylight Savings	
Trial 3 – Global Local Time Differential	

Session 5: Timebase Event Schedule Conformance Group Session

Feature	Comments
Trial 1 – Maximum Number of Time Base Schedule Entries	Tested all trials as part of Core Functions Testing. Remarks: See comments under findings IC-2 and TR-1.
Trial 2 – Time Base Schedule Table – Time Base Schedule Number	
Trial 3 – Time Base Schedule Table - Time Base Schedule Month of Year	
Trial 4 – Time Base Schedule Table - Time Base Schedule Day of Week	
Trial 5 – Time Base Schedule Table - Time Base Schedule Date	
Trial 6 – Time Base Schedule Table - Time Base Schedule Day Plan	
Trial 7 – Maximum Number of Day Plans	
Trial 8 – Maximum Number of Day Plan Events	
Trial 9 – Day Plan Table - Day Plan Number	
Trial 10 – Day Plan Table - Day Plan Event Number	
Trial 11 –Day Plan Table - Day Plan Hour	
Trial 12 – Day Plan Table - Day Plan Minute	
Trial 13 – Day Plan Table - Day Plan Action Number OID	
Trial 14 – Day Plan Status	

Session 6: Report Conformance Group Session

Feature	Comments
Trial 1 – Maximum Event Log Configurations	Not field tested. Remarks: See comments under finding AS-7.
Trial 2 – Event Log Configuration Table – Event Log Configuration ID	
Trial 3 – Event Log Configuration Table - Event Log Configuration Class	
Trial 4 – Event Log Configuration Table - Event Log Configuration Mode	
Trial 5 – Event Log Configuration Table - Event Log Configuration Compare Value	
Trial 6 – Event Log Configuration Table - Event Log Configuration Compare Value 2	
Trial 7 – Event Log Configuration Table - Event Log Configuration Compare Object Identifier	
Trial 8 – Event Log Configuration Table - Event Log Configuration Object Identifier	
Trial 9 – Event Log Configuration Table - Event Log Configuration Action	
Trial 10 – Maximum Event Log Size	
Trial 11 – Event Log Table - Event Log Class	
Trial 12 – Event Log Table - Event Log Number	
Trial 13 – Event Log Table - Event Log ID	
Trial 14 – Event Log Table - Event Log Time	
Trial 15 – Event Log Table - Event Log Value	
Trial 16 – Maximum Event Classes	
Trial 17 – Event Class Table – Event Class Number	
Trial 18 – Event Class Table - Event Class Limit	
Trial 19 – Event Class Table - Event Class Clear Time	
Trial 20 – Event Class Table - Event Class Description	
Trial 21 – Event Class Table - Event Class Number Of Rows In Event Log Table	

Session 7: STMP Conformance Group Session

Feature	Comments
Trial 1 – Dynamic Object Persistence	Not tested. Remarks: These features were not tested due to the following reasons: • Did not identify any issues through the pre-standard analysis process (interviews, etc) • Optional Conformance Group

Session 8: PMPP Conformance Group Session

Feature	Comments
Trial 1 – Maximum HDLC Group Address	Not tested. Remarks: These features were not tested due to the following reasons: • Did not identify any issues through the pre-standard analysis process (interviews, etc) • Optional Conformance Group
Trial 2 – HDLC Group Address Table - HDLC Group Address Index	
Trial 3 – HDLC Group Address Table – HDLC Group Address	

1203 (TS 3.6) NTCIP – Object Definitions for Dynamic Message Signs

Session 1: Sign Configuration and Capability Conformance Group Tests

Feature	Comments
Trial 1 – Sign Type	All features tested under product testing. No issues to report.
Trial 2 – Beacon Type	

Session 2: GUI Appearance Configuration Tests

Feature	Comments
Trial 1 – Sign Access	Not tested. Remarks: These features were not tested due to the following reasons: • Did not identify any issues through the pre-standard analysis process (interviews, etc) • Optional Conformance Group
Trial 2 – Sign Height	
Trial 3 – Sign Width	
Trial 4 – Horizontal Border Width	
Trial 5 – Vertical Border Width	
Trial 6 – Legend	
Trial 7 – Sign Technology	

Session 3: Font Configuration Conformance Group Test

Feature	Comments
Trial 1 – Number of Fonts	Not tested. Remarks: These features were not tested due to the following reasons: • Did not identify any issues through the pre-standard analysis process (interviews, etc) • Optional Conformance Group
Trial 2 – Font Table – Font Index	
Trial 3 – Font Table – Font Number	
Trial 4 – Font Table – Font Name	
Trial 5 – Font Table – Font Height	
Trial 6 – Font Table – Font Character Spacing	
Trial 7 – Font Table – Font Line Spacing	
Trial 8 – Font Table – Font Version ID	
Trial 9 – Maximum Characters per Font	
Trial 10 – Character Table – Character Number	
Trial 11 – Character Table – Character Width	
Trial 12 – Character Table – Character Bitmap	

Session 4: VMS Configuration Conformance Group Tests

Feature	Comments
Trial 1 – Character Height in Pixels	Not tested. Remarks: These features were not tested due to the following reasons: • Did not identify any issues through the pre-standard analysis process (interviews, etc) • Optional Conformance Group
Trial 2 – Character Width in Pixels	
Trial 3 – Sign Height in Pixels	
Trial 4 – Sign Width in Pixels	
Trial 5 – Horizontal Pitch	
Trial 6 – Vertical Pitch	

Session 5: Multi Configuration Conformance Group Tests

Feature	Comments
Trial 1 – Default Background Color	All features tested under product testing. No issues to report.
Trial 2 – Default Foreground Color	
Trial 3 – Default Flash On Time	
Trial 4 – Default Flash Off Time	
Trial 5 – Default Font	
Trial 6 – Default Line Justification	
Trial 7 – Default Page Justification	
Trial 8 – Default page On Time	
Trial 9 – Default page Off Time	
Trial 10 – Default Character Set	

Session 6: Message Table Conformance Group Tests

Feature	Comments

Trial 1 – Number Of Permanent Messages	All features tested under core functions, product, and exception testing. Remarks: See comments under finding TR-6
Trial 2 – Number Of Changeable Messages	
Trial 3 – Maximum Number of Changeable Messages	
Trial 4 – Free Bytes within Changeable Memory	
Trial 5 – Number of Volatile Messages	
Trial 6 – Maximum Number of Volatile Messages	
Trial 7 – Free Bytes within Volatile Memory	
Trial 8 – Message Memory Type	
Trial 9 – Message Number	
Trial 10 – Message MULTI String	
Trial 11 – Message Owner	
Trial 12 – Message CRC	
Trial 13 – Message Beacon	
Trial 14 – Message Pixel Service	
Trial 15 – Message Run Time Priority	
Trial 16 – Message Status	
Trial 17 – Validate Message Error	

Session 7: Sign Control Conformance Group Tests

Feature	Comments
Trial 1 – Control Mode	Tested a sample of the features under core function testing. No issues to report. Remarks: The ISTT tested only a sample of this session due to the following: • Tested and substantiated through the use of NTCIP Exerciser
Trial 2 – Activate Message Error	
Trial 3 – Software Reset	
Trial 4 – Activate Message	
Trial 5 – Message Display Time Remaining	
Trial 5 – Message Table Source	
Trial 6 – Message Requester ID	
Trial 7 – Message Source Mode	
Trial 8 – Memory Management	

Session 8: Default Message Control Conformance Group Tests

Feature	Comments
Trial 1 – Short Power Loss Recovery Message	Not tested. Remarks: These features were not tested due to the following reasons: • Did not identify any issues through the pre-standard analysis process (interviews, etc) • Optional Conformance Group
Trial 2 – Long Power Loss Recovery Message	
Trial 3 – Short Power Loss Time Definition	
Trial 4 – Reset Message	
Trial 5 – Communications Loss Message	
Trial 6 – Communications Loss Time Definition	
Trial 7 – Power Loss Message	
Trial 8 – End Duration Message	

Session 9: Pixel Service Conformance Group Tests

Feature	Comments
Trial 1 – Pixel Service Duration	Not tested. Remarks: These features were not tested due to the following reasons: • Did not identify any issues through the pre-standard analysis process (interviews, etc) • Optional Conformance Group
Trial 2 – Pixel Service Frequency	
Trial 3 – Pixel Service Time	

Session 10: MULTI Error Control Conformance Tests

Feature	Comments
Trial 1 – MULTI Syntax Error	Not tested. Remarks: These features were not tested due to the following reasons: • Did not identify any issues through the pre-standard analysis process (interviews, etc) • Optional Conformance Group
Trial 2 – Position of MULTI Syntax Error	
Trial 3 – Description of Other MULTI Error	

Session 11: Illumination / Brightness Conformance Group Tests

Feature	Comments
Trial 1 – Illumination Control	Tested all features under product and exception testing. Remarks: See comments under findings IC-4, TR-3, TR-5 and AS-10.
Trial 2 – Maximum Illumination Photocell Level	
Trial 3 – Status of Illumination Photocell Level	
Trial 4 – Number of Illumination Brightness Levels	
Trial 5 – Status of Illumination Brightness Level	
Trial 6 – Illumination Manual Level	
Trial 7 – Illumination Brightness Values	
Trial 8 – Brightness Values Error	
Trial 9 – Status of Illumination Light Output	

Session 12: Scheduling Conformance Group Tests (Global and DMS)

Feature	Comments
Trial 1 – Maximum Number of Time Base Schedule Entries	Tested all features under core functions testing and exceptions testing. Remarks: See comments under findings IC-2 and TR-1.
Trial 2 – Time Base Schedule Table	

Trial 3 – Maximum Number of Day Plan Events	
Trial 4 – Day Plan Table	
Trial 5 –Day Plan Status	
Trial 6 – Action Table Entries	
Trial 7 – Action Table	

Session 13: Auxiliary I/O Conformance Group Tests

Feature	Comments
Trial 1 – Maximum Number of Digital Auxiliary IOs	Not tested. Remarks: These features were not tested due to the following reasons: • Did not identify any issues through the pre-standard analysis process (interviews, etc) • Optional Conformance Group • See comments under findings AS-9.
Trial 2 – Maximum Number of Analog Auxiliary IOs	
Trial 3 – Auxiliary IO Table	

Session 14: Sign Status Conformance Group Tests

Feature	Comments
Trial 1 – Number of Rows in MULTI Field Table	Tested a sample of features under product testing. No issues to report.
Trial 2 – Pixel Failure Table	
Trial 3 – Current Speed	
Trial 4 – Current Speed Limit	
Trial 5 – Watchdog Failure Count	
Trial 6 – Open Door Status	

Session 15: Status Error Conformance Group Tests

Feature	Comments

Trial 1 – Short Error Status	Not tested. Remarks: These features were not tested due to the following reasons: • Did not identify any issues through the pre-standard analysis process (interviews, etc) • Optional Conformance Group
Trial 2 – Controller Error Status	

Session 16: Pixel Error Status Subconformance Group

Feature	Comments
Trial 1 – Number of Rows in Pixel Failure Table	Tested all features under product testing. No issues to report.
Trial 2 – Pixel Failure Table	
Trial 3 – Pixel Test Activation	

Session 17: Lamp Error Status Conformance Group Tests

Feature	Comments
Trial 1 – Stuck On Lamp Failure	Not tested. Remarks: These features were not tested due to the following reasons: • Did not identify any issues through the pre-standard analysis process (interviews, etc) • Optional Conformance Group
Trial 2 – Stuck Off Lamp Failure	
Trial 3 – Lamp Test Activation	

Session 18: Fan Error Status Conformance Group Tests

Feature	Comments
Trial 1 – Fan Failure	Not tested. Remarks: These features were not tested due to the following reasons: • Did not identify any issues through the pre-standard analysis process (interviews, etc) • Optional Conformance Group
Trial 2 – Fan Test Activation	

Session 19: Power Status Conformance Group Tests

Feature	Comments
Trial 1 – Sign Volts	Tested under exception testing. Remarks: See comments under findings IC-3, TR-4, and AS-8.
Trial 2 – Low Fuel Threshold	
Trial 3 – Fuel Level	
Trial 4 – Engine RPM	
Trial 5 – Line Volts	
Trial 6 – Power Source	

Session 20: Temperature Status Subconformance Group Tests

Feature	Comments
Trial 1 – Minimum Temperature of Control Cabinet	Tested under product testing. Remarks: See comments under findings AS-1.
Trial 2 – Maximum Temperature of Control Cabinet	
Trial 3 – Minimum Ambient Temperature	
Trial 4 – Maximum Ambient Temperature	
Trial 5 – Minimum Temperature of Sign Housing	
Trial 6 – Maximum Temperature of Sign Housing	

2301 (TS 3.STMF) NTCIP - STMF Application Profile

Session 1: SNMP Profile Requirements List

Feature	Comments
Trial 1 – Profile Requirements List	Tested through a structured interview (questionnaire) with vendors. No issues to report. Remarks: See general comment under finding AS-2.
Trial 2 – STMF Level 1 Global Statement of Conformance	
Trial 3 – STMF Level 2 Global Statement of Conformance	
Trial 4 – Basic Requirements – SNMP Implemented	
Trial 5 – Basic Requirements – SMI Implemented	
Trial 6 – Basic Requirements – MIB II Implemented	
Trial 7 – Basic Requirements – STMP (Section 5.1) Implemented	
Trial 8 – Basic Requirements – NEMA_SMI (Annex A) Implemented	
Trial 9 – Basic Requirements – TMIB (Annex B) Implemented	
Trial 10 – Basic Requirements – Class B MIB, Annex B Implemented	

Session 2: SNMP PICS PROFORMA

Feature	Comments
Trial 1 – Device Capable of Acting as SNMP Management Station	Tested through a structured interview (questionnaire) with vendors. No issues to report. Remarks: See general comment under finding AS-2.
Trial 2 –Generate SNMP GetRequest	
Trial 3 – Generate SNMP GetNextRequest	
Trial 4 – Generate SNMP SetRequest	
Trial 5 –Receive SNMP GetResponse	
Trial 6 – Receive SNMP Trap	
Trial 7 – Implementation capable of acting as SNMP Managed Agent	
Trial 8 – Generate SNMP GetResponse	
Trial 9 – Generate SNMP Trap	
Trial 10 – Receive SNMP GetRequest	
Trial 11 – Receive SNMP GetNextRequest	
Trial 12 – Receive SNMP SetRequest	
Trial 13 – Modify “views” per community name	
Trial 14 –message	
Trial 15 – version	
Trial 16 – Community	
Trial 17 – Data	
Trial 18 – PDU Format (except TRAP PDU) – request-id	
Trial 19 – PDU Format (except TRAP PDU) – error status	
Trial 20 – PDU Format (except TRAP PDU) – noError	
Trial 21 – PDU Format (except TRAP PDU) – tooBig	
Trial 22 – PDU Format (except TRAP PDU) – noSuchName	
Trial 23 – PDU Format (except TRAP PDU) – badValue	
Trial 24 – PDU Format (except TRAP PDU) – readOnly	
Trial 25 – PDU Format (except TRAP PDU) – genErr	
Trial 26 – PDU Format (except TRAP PDU) – error-index	
Trial 27 – PDU Format (except TRAP PDU) – variable-bindings	
Trial 28 – PDU Format (except TRAP PDU) – name	
Trial 29 – PDU Format (except TRAP PDU) – value	

Trial 30 – TRAP PDU format – enterprise	
Trial 31 – TRP PDU format – agent-addr	
Trial 32 – TRAP PDU format – generic-trap	
Trial 33 – TRAP PDU format – coldStart	
Trial 34 – TRAP PDU format - warmStart	
Trial 35 – TRAP PDU format – linkDown	
Trial 36 – TRAP PDU format – linkUP	
Trial 37 – TRAP PDU format – authenticationFailure	
Trial 38 – TRAP PDU format – egpNeighborLoss	
Trial 39 – TRAP PDU format – enterpriseSpecific	
Trial 40 – TRAP PDU format – specific-trap	
Trial 41 – TRAP PDU frmat – time-stamp	
Trial 42 – RAP PDU format – variable-bindings	
Trial 43 – TRAP PDU format - name	
Trial 44 – TRAP PDU format – value	

Session 3: Network SMI PICS PROFORMA

Feature	Comments
Trial 1 – Internet	Tested through a structured interview (questionnaire) with vendors. No issues to report. Remarks: See general comment under finding AS-2.
Trial 2 – directory	
Trial 3 – mgmt	
Trial 4 – experimental	
Trial 5 – private	
Trial 6 –enterprises	
Trial 7 –type	
Trial 8 – ObjectSyntax	
Trial 9 –simple	
Trial 10 – number	
Trial 11 –string	
Trial 12 – object	
Trial 13 –empty	
Trial 14 – application-wide	

Trial 15 – networkaddress	
Trial 16 – ipaddress	
Trial 17 – counter	
Trial 18 – gauge	
Trial 19 –ticks	
Trial 20 – opaque	
Trial 21 – Access	
Trial 22 – read-only	
Trial 23 – read-write	
Trial 24 –write-only	
Trial 25 – not-accessible	
Trial 26 – Status	
Trial 27 – mandatory	
Trial 28 –optional	
Trial 29 – obsolete	
Trial 30 –deprecated	
Trial 31 – value	
Trial 32 – ObjectName	

Session 4: NETWORK MIB PICS PROFORMA

Feature	Comments
Trial 1 – MIB Group – system	Tested through a structured interview (questionnaire) with vendors. No issues to report. Remarks: See general comment under finding AS-2.
Trial 2 – MIB Group – snmp	
Trial 3 – The System Group - sysDescr	
Trial 4 – The System Group – sysObjectID	
Trial 5 – The System Group – sysUpTime	
Trial 6 – The System Group – sysContact	
Trial 7 – The System Group – sysName	
Trial 8 – The System Group – sysLocation	
Trial 9 – The System Group – sysServices	
Trial 10 – The SNMP Group – snmpInPkts	

Trial 11 – The SNMP Group – snmpOutPkts	
Trial 12 – The SNMP Group – snmpInBadVersions	
Trial 13 – The SNMP Group – snmpInBad Community Names	
Trial 14 – The SNMP Group – snmpInBad CommunityUses	
Trial 15 – The SNMP Group – snmpInASNParseErrs	
Trial 16 – The SNMP Group – snmpInTooBigs	
Trial 17 – The SNMP Group – snmpInNoSuchNames	
Trial 18 – The SNMP Group – snmpInBadValues	
Trial 19 – The SNMP Group – snmpInReadOnlys	
Trial 20 – The SNMP Group – snmpGenErrs	
Trial 21 – The SNMP Group – snmpInTotalReqVars	
Trial 22 – The SNMP Group – snmpInTotalSetVars	
Trial 23 – The SNMP Group – snmpInGetRequests	
Trial 24 – The SNMP Group – snmpInGetNexts	
Trial 25 – The SNMP Group – snmpInSetRequests	
Trial 26 – The SNMP Group – snmpInGetResponses	
Trial 27 – The SNMP Group – snmpInTraps	
Trial 28 – The SNMP Group – snmpOutTooBigs	
Trial 29 – The SNMP Group – snmpOutNoSuchNames	
Trial 30 – The SNMP Group – snmpBadValues	

Session 5: STMP PICS Proforma

Feature	Comments
Trial 1 – Implementation Capable of Acting as STMP Management Station	Tested through a structured interview (questionnaire) with vendors. No issues to report. Remarks: See general comment under finding AS-2.
Trial 2 – Generate STMP GetRequest	
Trial 3 – Generate STMP GetNextRequest	
Trial 4 – Generate STMP SetRequest	
Trial 5 – Generate STMP SetRequest-NoReply	
Trial 6 – Generate STMP GetResponse	
Trial 7 – Generate STMP SetResponse	
Trial 8 – Receive STMP Trap	

Trial 9 – Receive STMP Error	
Trial 10 – Implementation Capable of Acting as STMP Managed Agent	
Trial 11 – Receive STMP GetRequest	
Trial 12 – Receive STMP GetNextRequest	
Trial 13 – Receive STMP SetRequest	
Trial 14 – Receive STMP SetRequest-NoReply	
Trial 15 – Receive STMP GetResponse	
Trial 16 – Receive STMP SetResponse	
Trial 17 – Generate STMP Trap	
Trial 18 – Generate STMP Error	

Session 6: SMI PICS Proforma

Feature	Comments
Trial 1 – nema	Tested through a structured interview (questionnaire) with vendors. No issues to report. Remarks: See general comment under finding AS-2.
Trial 2 – mgmt	
Trial 3 – experimental	
Trial 4 – private	
Trial 5 – transportation	

Session 7: TMIB PICS Proforma

Feature	Comments
Trial 1 – Byte	Tested through a structured interview (questionnaire) with vendors. No issues to report. Remarks: See general comment under finding AS-2.
Trial 2 – UByte	
Trial 3 – Short	
Trial 4 – UShort	
Trial 5 – Long	

Trial 6 – ULong	
Trial 7 – EntryStatus	
Trial 8 – OwnerString	
Trial 9 – protocols	
Trial 10 – layers	
Trial 11 – profiles	
Trial 12 – dynObjMgmt	
Trial 13 – dynObjData	
Trial 14 – devices	
Trial 15 – dynObjDef	
Trial 16 – dynObjEntry	
Trial 17 – dynObjNumber	
Trial 18 – dynObjIndex	
Trial 19 – dynObjVariable	
Trial 20 – dynObjOwner	
Trial 21 – dynObjStatus	
Trial 22 – dynObjConfigOwner	
Trial 23 – dynObjConfigStatus	
Trial 24 – adminCommunityName	
Trial 25 – maxCommunityNames	
Trial 26 – communityNameTable	
Trial 27 – communityNameTableEntry	
Trial 28 – communityNameIndex	
Trial 29 – communityNameString	
Trial 30 – communityNameAccessMask	

2101 (TS 3.PMP232) NTCIP - Point-to-Multipoint Protocol/RS232 Subnetwork Profile

Session 1: Physical Layer

Feature	Comments
Trial 1 – EIA/TIA-232-E Interface	Tested through a structured interview (questionnaire) with vendors. No issues to report. Remarks: See general comment under finding AS-2.
Trial 2 – EIA/TIA-232-E Data Rate and Programmable Bit Rates	
Trial 3 – EIA/TIA-232-E Duplexing	
Trial 4 – EIA/TIA-232-E Buffering	

Session 2: Data Link Layer

Feature	Comments
Trial 1 – Protocol Parameters	Tested through a structured interview (questionnaire) with vendors. No issues to report. Remarks: See general comment under finding AS-2.
Trial 2 – Frame Structure	
Trial 3 – Modes of Operation	
Trial 4 – Frame Types	

Session 3: RFC 1317 Management Information Base (MIB)

Feature	Comments
Trial 1 – Number of RS2323 Ports	Tested through a structured interview (questionnaire) with vendors. No issues to report. Remarks: See general comment under finding AS-2.
Trial 2 – RS232 Port Table (Mandatory - mandatory table objects includers232PortIndex, rs232PortType, rs232PortInSpeed, and rs232PortOutSpeed)	
Trial 3 – RS232 Asynchronous Port Table (Mandatory - mandatory table objects includers232AsyncPortIndex, rs232AsyncPortFramingErrs, and rs232AsyncPortOverrunErrs)	
Trial 4 – EIA/TIA-232-E Buffering	

Session 4: RFC 1381 MIB

Feature	Comments
Trial 1 – Link Access Protocol-Balanced (LAPB) Read-Write Table (Mandatory - mandatory table objects include lapbAdmnIndex, lapbAdmnTransmitN1FrameSize, lapbAdmnReceiveN1FrameSize, lapbAdmnT1AckTimer, lapbAdmnT2AckDelayTimer, lapbAdmnT3DisconnectTimer, and lapbAdmnT4IdleTimer)	Tested through a structured interview (questionnaire) with vendors. No issues to report. Remarks: See general comments under finding AS-2 and AS-4.
Trial 2 – Link Access Protocol-Balanced (LAPB) Read Table (Mandatory - mandatory table object includes lapbOperIndex and lapbOperPortId)	

Session 5: 1201 (TS 3.4) MIB

Feature	Comments
Trial 1 – Maximum HDLC Group Address	Tested through a structured interview (questionnaire) with vendors. No issues to report. Remarks: See general comment under finding AS-2.
Trial 2 – HDLC Group Address Table	

Tab D – Findings & Recommendations Summary for SDO

IC-1: Global Local Time

Discussion: Both vendors stated that they had problems with Global Time. It was not tied to a particular time zone. A subsequent amendment added a Global Local Time object that remedied the problem for the most part. A residual issue is that under some circumstances (day light saving time), one could SET a time and GET a time so the values would not match. One vendor chose to implement a Global Time DST Differential. Both sought guidance on daylight savings time objects and subsequently, both choose to implement the Amendment to 1201 Global Object Definitions (TS 3.4) that contained updates to the globalTime objects. There was some project and technical risk in doing this since at that time, the referenced amendment was still in DRAFT status.

Reference: see TR-2 for overall recommendation.

IC-2: Scheduler

Discussion: Both vendors expressed great displeasure with the Scheduler object. They stated that there is a problem with the override of a scheduler task without clearing the scheduler table. There is no global mechanism to enable or disable the scheduler. Both vendors created custom objects to overcome this issue.

Reference: see TR-1 for overall recommendation.

IC-3: Power Supply

Discussion: The standards provide for a single power supply on a sign. DMS signs have multiple power supplies and these are not addressed. The solutions implemented by the vendors were dissimilar: one deciding in favor of custom objects, the other using the Auxiliary I/O definitions in the higher-order standard (e.g., Global Object Definitions) which provides for analog and digital I/O ports but does not specify exact use. This omission by the standard leads manufacturers to come up with different implementations.

Reference: see TR-4 for overall recommendation.

IC-4: Multiple Light Sensors

Discussion: Similarly, the DMS standards provide for only one photocell (i.e., an ambient light sensor). Both vendors were required to implement three of these illumination sensors as required in the ISTHA Request for Proposal (RFP). They also mentioned the fact that virtually all RFPs will require multiple sensors. The solutions implemented by the vendors were dissimilar: one approach taken was to create custom objects, the other approach was to use the Auxiliary I/O definitions in the higher-order

standard (e.g., Global Object Definitions) which provides for analog and digital I/O ports but does not specify exact use. This omission by the standard leads manufacturers to come up with different implementations.

Reference: see TR-3 for overall recommendation.

IC-5: No Capability to do Graphics

Discussion: Both vendors commented that another stated shortcoming in the standard was that there is no capability to do graphics.

Recommendation: No action.

IC-6: Lack of Communications to obtain Guidance on NTCIP Standards

Discussion: A general comment that was raised by both vendors was that there needed to be a better communications channel for obtaining information on the NTCIP standards, submitting comments and suggestions related to the standards, and obtaining help on their usage. Additionally, they found it difficult to obtain information related to referenced standards such as those developed by ISO.

Recommendation: Better inform users on the process for obtaining help on standards usage, and for submission of comments and suggestions.

TR-1: Scheduler Object

Upon analysis of the core functions captured data, the standard had deviations related to DMS scheduler functionality. There were 138 discrepancies out of a total of 3,049 data packets that were analyzed.

Discussion: As shown above, the scheduling action object is addressed under standard 1203 for some objects, and the rest are addressed under 1201 for global objects. During the interview process, both vendors identified that the scheduler related portions of the NTCIP - Object Definitions for Dynamic Message Signs (1203) standard were deficient. Both vendors sought additional guidance from NEMA related to this issue. The standards, though addressing most of the objects, do not define an object for enabling or disabling the scheduler. The solution to address the lack of this object and remain compliant with NTCIP standards was to create a custom object. See IC-2 for interview comments.

Recommendations:

The standards (both 1201 & 1203) need to be enhanced to include an object to enable and disable the scheduler.

1. A companion document that could serve as a users guide could be developed to assist the vendors in implementing the scheduler objects.

TR-2: Global Local Time Differential

In the standard 1201, Global Time is not tied to a particular time zone. A subsequent amendment to 1201 added a Global Local Time Differential object that remedied the problem for the most part.

Discussion: Both the vendors tried to receive guidance on daylight savings time objects from the standards organizations and NEMA, then they both choose to implement the Amendment to 3.4 that contained updates to the `globalTime` objects (which was still in draft format). See IC-1 for interview comments.

Recommendations:

2. The process for publishing standards amendments should be expedited.
3. The SDOs should provide improved access for inquiries, and information to vendors who use these standards to inform them (the vendors) of changes.

TR-3: Support for Multiple Light Sensors

The applicable standards (1201, 1203) do not support multiple light sensors.

Discussion: As shown above, the standard provides suitable access for DMS technology using no more than one illumination photocell. There are at least three compliant yet often divergent interpretations or solutions to this omission or limitation by the standards: (1) use only one light sensor, (2) creation and use of custom objects, or (3) use of alternative objects in the standard. Generally:

4. The use of only one light sensor is unreasonable given that most of the RFPs for DMS state the requirement for multiple (usually 3) light sensors.
5. The creation and use of custom objects is a solution that works but this clearly leads to a situation of interoperable but non-interchangeable subsystems.
6. The use of more general purpose objects, for example, 1203 (DMS Objects) includes analog and digital I/O ports that can be addressed as individual objects (e.g., `analogIOPort.X`, `digitalIOPort.X`). The use of these objects to acquire status and manage "analog" and "digital" subassemblies and components is, on one hand, innovative yet again, divergent from interoperability/interchangeability of DMS subsystems.

See IC-3 for interview comments.

Recommendations:

7. The standard should be modified to include coverage of one or more illumination brightness sensors. In the style of the existing objects, this might take the form:

```
[ maxDMSIllumControls, numDMSIllumControls ]
dmsIllumControl.X
dmsIllumMaxPhotocellLevel.X
dmsIllumPhotocellLevelStatus.X
```

   where `maxDMSIllumControls` and `numDMSIllumControls` objects could indicate the maximum number and number of currently installed or active sensors, respectively; the "X" then indicates available access to a specific table object within that scope.

8. The 1203 (DMS) standard could be modified to recommend that this situation be implemented by using the analog or digital I/O ports described elsewhere in 1203. However, this solution still leaves room for vendor interpretation leading to interoperable but non-interchangeable subsystems.

9. A companion document (e.g., 1201, 1203 DMS NTCIP User's Guide) could be developed to guide the vendor and application developers.

TR-4: Support for Multiple Power Supplies

The applicable standards (1201, 1203) do not support multiple power supplies.

Discussion: As shown above, the standard provides rather limited coverage of what appears to be a fossil-fueled, rotating-engine powered DMS; with limited access to potentially useable features like line voltage and sign voltage and no access to useful status information. At best, with atypical interpretation and usage, it provides access to a DMS technology using no more than one power supply. There are at least three compliant yet often divergent interpretations or solutions to this omission or limitation by the standards: (1) use only one power supply, (2) creation and use of custom objects, or (3) use of alternative objects in the standard. The following discussion applies and has been de-identified as to any specific vendor or implementation.

10. The use of only one power supply is unwise and unreasonable given that most DMS would require robust and redundant power to both digital and analog circuitry in the sign(s) and the accompanying control cabinetry, and for power to sign heaters and fans in some applications.
11. The creation and use of custom objects is a solution that works but this clearly leads to a situation of interoperable but non-interchangeable subsystems.
12. The use of a more general object; for example, 1203 (DMS Objects) includes analog and digital I/O ports that can be addressed as individual objects (e.g., `analogIOPort.X`, `digitalIOPort.X`). The use of these objects to acquire

status and manage "analog" and "digital" power supplies as subassemblies and components is, on one hand, innovative yet again, divergent from interoperability/interchangeability of DMS subsystems.

See IC-4 for interview comments.

Recommendations:

13. The standard should be modified to include coverage of one or more power supplies. In the style of the existing objects, this might take the form:

```
[ maxPowerSources, numPowerSources ]
dmsPowerSourceType.X (1)
dmsPowerSourceStatus.X (2)
dmsPowerSourceActivate.X
```

where `maxPowerSources` and `numPowerSources` objects could indicate the maximum number and number of currently installed or active power sources, respectively; the "X" then indicates available access to a specific table object within that scope. Note: (1) could provide an enumerated list of power supply types as an extension of that shown for `powerSource` in the existing standard, and (2) could provide access to a double-indexed table item allowing a level of sophistication in sampling power supply status (e.g., `powerSourceStatus.n.m` representing power supply "n", status item "m").

14. The 1203 (DMS) standard could be modified to recommend that this situation be implemented by using the analog or digital I/O ports described elsewhere in 1203. However, this solution still leaves room for vendor interpretation leading to interoperable but non-interchangeable subsystems.

15. A companion document (e.g., 1201, 1203 DMS NTCIP User's Guide) could be developed to guide the vendor and application developers.

TR-5: Illumination Brightness

While conducting the data analysis for the tests related to the dmsIllumBrightnessValues object, it was discovered that a varied approach to defining the brightness levels existed between the vendors. The standard indicates that a range defined by the entities known as photocell level down and photocell level up define each brightness level. These entities are a function of the sign's photocell detection of ambient light.

Discussion: The number of levels defined by one vendor is twenty. The other vendor maintains 255 levels of brightness. One vendor uses sequential numbering of their brightness levels with non-overlapping sequential ranges for the photocell level down and photocell level up. The other vendor uses non-sequential brightness and photocell levels in conjunction with a custom object to provide the intended functionality of the object. Neither vendor uses a linear scale as specified in the standard.

Recommendation: Consider the implementation of objects that enable the setting of the brightness level, as well as recording the current level of brightness, as a percentage of the maximum illumination of the photocell.

TR-6: Message MultiString CRC

During the test it was discovered that the activation of a message on a vendor's sign is inextricably linked to the values of the beacon and pixel service objects associated with the message. The standard defines that the `dmsMessageCRC` value is the CRC-16 calculation of the message multistring, and the settings for beacons and pixel service. This important CRC value is used in activating messages as well as identifying messages for use by other objects. When a message is created and saved to the sign, the sign calculates the CRC and uses it to compare against the value sent when trying to activate a message. Thus, it is imperative that whenever a message is requested for display that the CRC value sent in the activation request and that stored in the sign are exact. Therefore, the state of the beacon and pixel service objects must be the same when activating a message as there were set when creating and storing the message or an error will occur and the message will not be displayed on the sign.

Discussion: On-site analysis of the calculated message CRC, verified by subsequent analysis of the collected data packets, showed inconsistencies in the values used to set the beacon and pixel service objects. These inconsistencies were apparent when utilizing the vendor's control software to create, set, and activate messages. One vendor choose to set each of these objects to a default value of 0, indicating that the beacon and pixel service objects are to disabled. The setting of these objects with the other vendor's software package was unintuitive. Further investigation showed that enabling the pixel service object also enabled the beacon object. However, enabling the beacon object did not enable the pixel service object. Additionally, the vendor chose to use these two objects set to 1 (enabled) as the default condition.

Recommendations:

16. Emphasize the importance of identifying the default settings for the beacon and pixel service objects. Encourage each vendor to identify the default settings for these objects and the manner in which to change them.
17. Provide information to the user on the importance of the beacon and pixel service objects when activating a message. While this information should not be considered part of the base standard, it may improve the compatibility and usability

of the products, if it were to be disseminated in a standard companion document such as a lessons learned or operational guide.

AS-1: Maximum Temperature of Sign Housing Parameter

Upon analysis of the 1203 (TS 3.6) standard, it was discovered that this object's valid integer range is defined as 0-255. All of the remaining temperature objects in the Temperature Conformance Group have a valid integer range of -128 to +127.

Discussion: The inability to set negative integer values for this object may impact the execution of actions when this object is used to compare against a threshold level. As implemented at ISTHA, this object does not perform in this capacity and is presumably used for reporting purposes only.

During the test and subsequent data analysis, it was discovered that the values for the minimum and maximum temperatures for related objects (i.e., `tempMinAmbient` and `tempMaxAmbient`) return the same value. This raises the question as to whether the temperature objects are used in a capacity other than reporting purposes, whether the vendor's have implemented them correctly, or whether they are functional.

Recommendations

Draft an amendment to the standard that corrects the valid range to –128 to +127.

AS-2: External Reference Consistency Issues

In ITS standards 1101, 2001, 2301 and 2101 (i.e., TS 3.2, 3.3, 3.STMF and 3.PMP232 resp.), a number of non-ITS standards have been used to define the operation and interaction of hardware and software components, systems, and articles related to Dynamic Message Signs. Standards from various bodies such as ISO, IEC, EIA, TIA, and IEEE define items such as timing, protocols, managed objects, and data packet structures used in the implementation of an NTCIP DMS subsystem.

Discussion: Use of non-ITS standards expedite the implementation of standardized DMS as many of these standards have been ratified and successfully deployed in operating environments for many years. These standards typically define the underlying data communications layers that enable control stations to configure and operate the DMS. However, in many cases information contained in these standards may be difficult to acquire and understand. Information from trustworthy sources can be limited, hard to find, and in some cases, difficult to acquire. For instance, ISO standards must be purchased and can be expensive. Additionally, the information contained within the standards may be difficult to interpret. Items such as those listed below, that are defined in these standards, must be interpreted in the same manner in order to provide interoperability/interchangeability:

18. Group addressing
19. Short and long form length encodings for TLV (tag-length-value) data structures
20. BER/OER encoding rules
21. 2' s complement encoding
22. HDLC bit stuffing/transparency
23. CRC-16 calculation

Recommendation: Maintain dialogue with vendors regarding problems interpreting and implementing "non-ITS" standards. If warranted, provide additional guidance or clarification to items contained within these standards. This information could be contained within a companion document to the standard.

AS-3: Network Layer

Analysis of the 2001 standard (Class B Profile) noted a discrepancy in defining the functions and services of the Network layer.

Discussion: Introductory text in Section 2.2.4 of the 2001 (TS 3.3) standard describes the general aspects of the Network Layer as being null or empty. However, Section 3.4 of the standard indicates that a minimal amount of functionality is required in the Network Layer and further specifies the characteristics of this functionality.

Recommendation: Conduct proceedings to draft an amendment to the base standard that clarifies the discussion of the Network Layer specifications.

AS-4: LAPB MIB Objects

Analysis of the 2001 (TS 3.3 – Class B Profile) standard noted a discrepancy in the Link Access Protocol – Balanced (LAPB) objects to be supported by a standards compliant product.

Discussion: The 2001 (Class B Profile) base standard introduced support for a number of objects within the `lapbOperTable` object as defined in RFC 1381. A draft amendment to the base standard, Amendment 1, changed the support of these objects to corresponding objects in the `lapbAdmnTable` with one exception, `lapbOperPortID`. RFC 1381 does not have a corresponding `lapbAdmnPortId` object, therefore, it is speculated that the inclusion of the `lapbOperPortID` is correct, or that RFC 1381 is incomplete. Speculating that RFC 1381 is correct leads to the following. The `lapbOperPortID` object is an entry in the `lapbOperTable` object. Since the `lapbOperPortID` object is contained within a table object, it can only be accessed through the table's index (`lapbOperIndex`) thus, the `lapbOperIndex` object must be supported. Additionally, in order to support the `lapbOperIndex` object, the `lapbOperEntry` and `lapbOperTable` objects must be supported as well.

Recommendation: Obtain clarification on support of an object named `lapbAdmnPortID` in RFC 1381 from the Internet Activities Board (IAB). If RFC 1381 is flawed, in that it supports an object named `lapbAdmnPortID, then` modify Amendment 1 to reflect support of the `lapbAdmnPortID` object. If RFC 1381 is correct, add support for the `lapOperTable`, `lapbOperEntry`, and `lapbOperIndex` objects in Amendment 1.

AS-5: Gauge Syntax

Analysis of draft Amendment 1 to the 1201 (TS 3.4) standard showed the use of a previously undefined object syntax, gauge.

Discussion: The Global Object Definitions Amendment 1 added support for a mandatory Security Conformance Group. Within this group, a mandatory object named `communityNameAccessMask` is defined as a 32-bit mask that can be used to associate "write access" to objects within a community name. The syntax chosen for this object is of type gauge that has no reference in the base standard or the amendment. In order to successfully compile a MIB, every object syntax must be defined in the MIB or included within an import statement. Neither of these conditions exists in either the base standard or the amendment.

Recommendation: Modify 1201 (TS 3.4) Amendment 1 to include an import statement of the gauge syntax from RFC 1155.

AS-6: Community Name Index

Analysis of draft Amendment 1 to the 1201 (TS 3.4) standard showed the access setting of the `communityNameIndex` object as not-accessible.

Discussion: The Global Object Definitions Amendment 1 added support for a mandatory Security Conformance Group. Within this group, a mandatory object named `communityNameIndex` is defined as the index to the rows contained within the `communityNameTable` object. The community name table provides flexibility and security in manipulating MIB objects within 1201 and other standards and is a potentially valuable feature. Unlike all other table index objects providing access to entries in a table, this object is marked as not-accessible, indicating that it can not be used to access and manipulate values within the table.

Recommendation: Modify Amendment 1 to change the access type of the `communityNameIndex` object to read-only.

AS-7: Event Configuration Mode

Analysis of the 1201 (TS 3.4) base standard and draft Amendment 1 to the standard indicated the use of an undefined object.

Discussion: The Global Object Definition Amendment 1 defines an object named `eventConfigMode`. The valid syntax is an enumerated integer. The description of the second listing, `onChange`, indicates that a log entry is to be created when the value referenced by the `eventTypeOID` changes. It is speculated that the correct object to be referenced for this mode is the `eventConfigCompareOID`. Additionally, it is implied that only objects that are defined with integer syntax can be used for the `greaterThanValue`, `smallerThanValue`, and `hystersisBound` configuration modes.

Recommendations:

1. Modify 1201 (TS 3.4) Amendment 1 to change the description of the referenced object for the `onChange` configuration mode to `eventConfigCompareOID`.
2. Investigate the use of other types of syntax for the `eventConfigCompareValue` objects.

AS-8: Low Fuel Threshold

Analysis of the 1203 (TS 3.6) base standard indicated a range that could be in error.

Discussion: The low fuel threshold object (`lowFuelThreshold`) syntax is an integer whose range is 0 to 255. This object indicates the level of fuel in the tank, as a percentage of the total capacity of the tank. This object's intention is to alert the user to a possible low fuel condition. As a percentage, the valid range of should be 0 to 100.

Recommendation: Modify the standard with an amendment that lists the valid range of the `lowFuelThreshold` object from 0 to 100.

AS-9: 1203(TS 3.6 Standard Typographical Issues and Edits

A collection of minor editing inconsistencies and errors found in 1203 (TS 3.6).

Discussion: In the course of analyzing the 1203 (TS 3.6) standard, a number of minor typographical or editing errors were noticed. These items are listed below:

1. Section 3.4 contains a table listing the flags that can be used with the MULTI syntax language. The Spacing Character tag should include a closing flag of "/sc" in the appropriate column.

2. Section 3.4.5 references objects named `fontDefinitionUserID`, `fontDefinitionIndex`, and `fontDefintion`. These objects should be named `fontNumber`, `fontIndex`, and `fontTable` respectively.

3. The MIB defined in the standard lists the names of two objects, `maxAuxIODigital` and `maxAuxIOAnalog` to describe the number of auxiliary digital and analog ports contained in the auxiliary port table, respectively. Section 4.13 of the standard, which details the objects contained in the Auxilliary I/O Conformance Group, lists these object names as `maxAuxAnalog` and `maxAuxDigital`. Additionally, the objects contained in the `auxTable` are labeled incorrectly in Section 4.13. The MIB shows the names of these objects to contain the string "IO" after "aux". This string is omitted in section 4.13 for the table objects.

4. The MIB defined in the standard lists the names of two objects as `dmsIllumBrightnessValuesError` and `dmsIllumBrightLevelStatus`. Section 4.11 of the standard, which details the objects contained in the Illumination/Brightness Conformance Group, lists these object names as `dmsIllumBrightnessValuesStatus` and `dmsIllumBrightStatus` respectively.

5. The MIB defined in the standard lists an object named `dmsMessageStatus`. Section 4.6 of the standard, which details the objects contained in the Message Table Conformance Group lists the name of this object as `dmsMessageMsgStatus`.

6. The `fontIndex` object has been defined with access of read-write-only. It is speculated that the access for this object should be marked as read-only.

7. The `defaultJustificationLine`, `defaultPageOn`, `defaultPageOff`, and `defaultCharactersSet` objects have been defined with an access of read-write-write. It is speculated that the access for these objects should be marked as read-write.

Recommendation: Modify the standard with an amendment that corrects these anomalies.

AS-10: 1203 (TS 3.6) Standard Clarifications

During the analysis of the 1203 (TS 3.6) standard a number of issues were identified where additional information could prove to be beneficial.

Discussion: In the course of analyzing the standard, a number of ambiguities or lack of information were uncovered and are detailed below:

1. The definition of the `MessageActivationCode` syntax does not define the unit of measurement for the duration of the message. It is speculated that the unit of measurement is minutes from information describing the functionality of the `dmsMessageTimeRemaining` object.

2. The standard does not define whether setting the bit to 0 or 1 indicates support of the identified value for the `dmsSignAccess` and `dmsSignTechnology` objects. It is speculated that setting a bit to 1 indicates support of the value assigned to that bit.

3. The temperature type fields in the MULTI language specification do not indicate whether this temperature is the ambient temperature or some other temperature value. It is speculated that the temperature value is the ambient temperature determined by the temperature device.

4. It is not clear what invalidating a row when setting `fontHeight` to 0 means. This could be interpreted as deleting the characters in the `characterTable` and all the font information in the `fontTable` for the particular font in order to free memory usage or simply to make these values unavailable.

5. The `dmsMessageTimeRemaining` is set to read-write. This implies that you could set this object to extend the duration of the currently displayed message. Is this functionality intended for this object?

6. The purpose of the `statMultiField` objects are unclear. The purpose of these objects could be inferred to indicate the current value of a MULTI language syntax field as displayed on a sign; or the value of each of these fields regardless of their use in a currently displayed message. If these objects intended usage are

characterized by the first assumption, could obtaining the MULTI string of the message in the current buffer provide the same information.

7. The purpose of the `watchdogFailureCount`, which describes the number of watchdog failures that have occurred, was unclear. Addition of information in the description of the object's purpose may be considered. Additionally, information concerning the epoch from which these counts have accumulated from may also provide beneficial. Perhaps an object providing the time since the `watchogFailureCount` was instantiated and an object to reset or clear the object may be of use.

Recommendations:

1. Investigate the insertion of information to clarify the issues identified herein for incorporation into a future amendment to the 1203 (TS 3.6) base standard.
2. Provide a complimentary document for the standard such as a implementation or guideline document that provides additional information for the issues identified herein.

AS-11: 1203 (TS 3.6) Standard Modifications

During the analysis of the 1203 standard, a number of issues were identified where modification to the standard could prove to be beneficial.

Discussion: In the course of analyzing the standard, a number of areas where additional objects and information may increase the usability and productivity of the standard were identified. These articles are listed below.

1. Consider using a 16-bit bitmap integer for the `dmsValidateMessageError` and `dmsActivateMessageError` objects instead of an enumerated integer. Use of the enumerated integer, as defined in the standard, only reports the last error observed if multiple errors are generated. Using a bitmap supports the identification of multiple error types by setting a bit to 1 if the error is observed. This approach can identify errors of multiple types.

2. Consider renaming the `maxAuxIODigital` and `maxAuxIOAnalog` objects. These objects describe the number of rows in the `auxIOTable` for the particular port type and not the maximum number supported by the table. Additionally, the addition of the values for the objects should not be greater than 255.

3. Consider adding objects for the beacon service that function similarly to the objects defined for pixel service related to the status error objects group

4. The pixel failure table should be cleared when the `pixelTestActivation` object is set to “test” (3) or “clearTable” (4).

5. Consider the addition of objects to support multiple fans, power supplies, and lamps, as well as objects describing the number of items, tables describing types, and test objects to initiate and report test conditions and results.

Recommendation: Investigate amending the standard with the articles detailed above after analyzing the effects of such additions and receiving input from various groups with a specific interest in the standard.

AS-12: Core Functions

Prior to the testing of the NTCIP standards related to Dynamic Message Signs, a collection of core functions were identified that characterize the behavior of a DMS. Testing of these functions was emphasized.

Discussion: In developing the procedures for testing DMS, various entities, such as the NTCIP Joint Committee, expressed concern over the lack of support for testing functions. A preliminary list of core functions was developed by the NTCIP Joint Committee and ISTT members and disseminated to interested parties, including DMS manufacturers. Each interested party had the opportunity to provide comments related to the accuracy and completeness of this list. The finalized list of core functions that would be addressed during the standards testing process is shown below:

Control Sign Display Functions

Display a message on a sign
Blank a sign

Create a Message Functions

Build a new message
Delete a message
New line
New page
Flash message
Justify line
Justify page
Select Font

Exceptional Sign Control Functions

Default display condition following end of message

Scheduled Control Functions

Configure time-base schedule
Configure day plan
Configure action table

Run the schedule

Monitor Sign Display Status Functions

Adjust display brightness
View active message
Detect pixel errors
Identify source of message

Recommendation: Generate a companion document to the standard, such as an implementation guide, that details the manipulation of objects, as envisioned by the SDO, to realize the core functions deemed essential for a DMS.